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MACHINE SUBSTITUTES FOR THE COMPOSITION OF TYPES BY HAND.*

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Viewed as one of the arts of design, printing has survived several distinct epochs of alternate exaltation and abasement; viewed as a mechanic art, its progress has been slowly but uninterruptedly towards increased perfectness of machinery and the acquirement of means whereby production is simplified, increased and cheapened. The developments of fifty years have been particularly revolutionary. A complete transformation has been wrought in original methods. The untiring inventive genius of the past several centuries effected its changes slowly at first; but to-day these are being inaugurated with such bewildering rapidity that the equipment of a modern

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printing office is antique long before the machinery comprising it is worn out. What is true of printing is true of the contemporaneous arts. The progress of one exactly parallels the progress of all industrial arts. There is an unremitting tendency to diminish the demands made by production upon the intelligence of the source of energy—which, in all handicraft, resides in the workman, and in all machines to a greater or lesser degree in the increased exactness of the motions therein embodied. It is the aim of modern invention to eliminate intermediary processes lying between the unworked material, in a raw state, and the finished industrial output. Nowhere is the correlation of formerly isolated functions better shown than in the giant rotary presses, which deliver miniature Niagaras of newspapers into the bins of the metropolitan dailies for distributing to the reading public. Printing, folding, inserting, pasting, recording and delivering are some of the combined performances of these machines, all automatically accomplished, in perfect synchronism, and at lightning speeds.

The supremacy of machine methods in printing is past mere hypothesis; alterations have taken place in almost all departments of the art. The functions of the compositor have alone resisted the assaults of invention. Why have not change and improvement succeeded in modifying the process of setting up types by hand? Apparently, type-setting is not a difficult operation. Observe the compositor at his case, composing stick in hand. One by one he lifts the letters from their respective compartments in the case and places them side by side into the stick, in the order of their use. Type follows type and line follows line until the stick is filled and its composed contents transferred to the galley, when the process begins again. Habit has rendered each function instinctual, and centuries of usage have canonized the practices of the art. In the precise way that the compositor of to-day does the work did the compositor of 400 years ago do it. There has not been a single radical change in the methods of the fraternity in all that time. Moreover, such influences as have been engendered by type-setting machines on the one hand, and by matrix-setting and

casting machines on the other hand, are yet too embryonic to have become essentially alterative. Upon a conservative estimate not more than 3,000 machines of all kinds are now in use in the United States, and of this number a large proportion is centralized in the offices of great dailies. The number of compositors amounts to more than 125,000, and they are increasing at the rate of 3,000 each year. Outside of isolated printing offices, here and abroad, it is only within the last ten years that machine substitutes for the composition of types by hand have been regarded as practical enough to justify attention on the part of the progressive printer. Certainly it is not because inventors have disregarded the problem or because the requisite talent has lain dormant. For seventy-five years attempts have multiplied to accelerate the process of type-setting, either by machines for handling foundry-made letter or by machines for doing away entirely with the manipulation of types thus made. In Great Britain, since 1822, several hundred patents have been taken out for this class of invention alone; in the remaining parts of Europe the number is in advance of this; in the United States a still greater number is recorded. Of all this immense expenditure of inventive talent, mechanical skill and, it may be added, of the funds needed to carry on the various experiments, the machines which have reached commercial stages may be numbered on the fingers of one hand. With such and with their archetypes it is the intention to deal, but only from the standpoint of principles, to which mere mechanical details will be strictly subordinated. The extent of the subject forbids more.

NATURE OF THE PROBLEM.

Why are the practices of type-setting crystallized, and why were type-composing machines so tardy in achieving practical efficiency? The truth is that, while apparently a very simple process, type-setting is, in reality, just the opposite. Its requirements are of a mental kind, and the part played by manual skill is of a secondary rather than a primary character. The hand of the compositor is but the servant of his mind; the latter indicates the road the first must travel in. Were copy

all alike, were types all of the same size and style, were words never divided at the end of the line, were lengths of lines an indifferent matter, it is more than probable that the first attempt to build a suitable mechanical substitute would have been successful. Lines, however, must be of approximately identical lengths among themselves in each measure employed; words will stubbornly refuse to occupy the given space; and type bodies cannot but vary setwise—from that bearing the full point and narrowest character to that bearing the widest character—in each size. One font also differs from another font in breadth to accord with the requirements of larger or smaller faces, and here the variation is bodywise. There is thus a two-fold variation, first as to width, second as to thickness. In length, all types are made to a supposedly uniform standard, which, with the American founders, ranges between ·918 and ·920 inch. An allowable deviation of one-half thousandth of an inch is not infrequent. Any height-variation exceeding this, either above or below the standard, is rejected.

Seven operations belong by rights to type-setting by hand. The compositor must (1) decipher his copy; (2) attend to its orthography and punctuation, according to the rule of the office in which he is working; (3) convert it into types and spaces; (4) uniformly apportion his spacing; (5) make-even his lines; (6) effect his corrections from proof-read sheet; (7) distribute his assembled types after they have served their use, either in printing or in electrotyping and stereotyping. These are the functions of the man, but are by no means all the essential factors to good type-setting. Neither in their entirety do they map out the machine problem. If the inventor does not aim to accomplish more than the assembling of the types and spaces and their ultimate distribution, his task ends with providing mechanisms to do what the compositor does in his work at the case. If the inventor aims to provide a printing surface of letterpress, in which he makes his own types or substitutes therefor, his desiderata extend beyond the domain of the compositor's art into that of the typefounder's. There are esthetic and mathematical considerations here to be dealt with.

A piece of first-class letterpress has three attributes, the presence of which ensures its excellence. These may be briefly enumerated. The first is evenness of impression, the lack of which in our newspaper printing furnishes its own commentary upon typographic deterioration. An even impression requires a surface the variation in parts of which shall neither require compensating for at the press by excessive make-ready nor manipulation of another kind. It is this exactness of height from foot to face of the types that permits of fine results in printing from foundry-letter of the best class.

The second requirement of good printing is perfectness of face, or unbroken continuity of line and curve over the entire surface which is to contact with the paper. This needs no amplification.

The third generalization is accuracy of alignment, the least departure from which fatally condemns a bit of printing as the fault of the workman who locks up the composed types into the printing-form, or else as the fault of the types themselves. In a word, the sin is either that of the stone-hand or of the material. This attribute of good printing requires the most accurate proportion and squareness of angles in the body of each letter that is used. If not to an approximate extent a perfect rectangle, the individual types comprising a line will not fit with the mutual closeness needed in a tight line; if not rectangular throughout their entire length of body they will "wabble" and rock. The same may be said of the feet of the types; they must be a perfect level, so far as practical perfection extends, and occupy a plane that is exactly at right angles with the plane of their sides.

Given the present conditions of publishing, it seems patent that under no system ever conceived will a preliminary functioning by intelligence be dispensed with in machine-work. There will always have to be operatives—at least as long as there is copy to be interpreted, bad grammar to be dealt with, and the caprices of writers for publication to complicate original manuscript.

Generally speaking, therefore, the task set the inventor in the field thus far traversed is to produce a machine which will

translate copy into properly spaced lines, pages, or galleys of lines of types. Each of the broad classes of machine substitute with which printers are at present familiarized has approached the question from opposite standpoints. Broadly considered, these machines fall into two classes, viz.: machines which handle foundry-type, and machines which not only compose the printing surface, but go further and make the types of which, whether singly or in lines, such surface is made up. The first class takes in all systems of type-setting, and relates to those machines in which the mechanical functions only partially cover the accomplishments of type-composition as manually practised, and in which, as a consequence, the chain of operations merely runs parallel with one or more parts played by hand labor in the finished product.

Into the second class of machine substitutes fall those machines in which the chain of operations transcends manual methods and includes all the functions necessary in accomplishing a letterpress printing surface. As mechanisms, these latter are evidently far broader in scope than the first class of machines for type-setting proper. Whatever may be the excellencies or defects of their product, which will be later considered, they embody systems of original character, which step over the limits of imitative processes. In them, the kinematical chain—that is, the series of motions, not only in themselves considered, but linked together with relation to consecutive processes and a well-defined end—is lengthened by augmentation of new motions, each with a view to enlarged efficiency. If these machines can be kept within the boundaries of reasonable proportions, and can be made to conserve the proper standards of quality, then they are undoubtedly the fittest to survive, being the most complete. In the words of a great German mechanician (Rouleaux), "the most complete machine is that which best fulfils its own share of the work and has for this share the greatest proportion of the whole task." Such a standard will afford a safe criterion of judgment in analyzing various systems.

The Archetypal Patent.—The first patent taken out for a mechanical type-setter was that of Dr. William Church, a na-

tive of New England, who went to Great Britain, in 1821, to introduce a printing press. In 1822, he patented a system for casting, composing and printing types. Some English pamphleteers have said that as far back as 1797 one Herhan, in England, proposed a scheme which underlay the archetypal form of composing machine, and that he applied for British letters-patent. A careful search of the records reveals no trace of the invention.

Dr. Church was the first to propose the keyboard idea, which, at some point or other of the operation, now pervades all classes of modern machinery in this field. Attempts have been made to dispense with keys, but the machines, while ingenious, have fallen below the level of efficiency exacted in practical work, and since made possible by digital skill, either wholly or partially used.

The Church machine comprised three parts: First, a machine for casting the printing types, and also of arranging them in boxes of letters, so that the types of the same denomination were placed side by side in ranges, ready to be transferred to the composing machinery. The second part was a machine for selecting and composing the individual types into words and sentences. The third part was a process of printing and of delivering the sheets in a pile, thus involving a third machine. Distribution was no doubt to be effected by throwing the used types into the melting pot and recasting them.

After casting his individual types, which were delivered in rows and stored in separate upright receptacles in the composing machine, Dr. Church provided mechanism to bring them into assembly. Each row of types was located directly over a slot in a bottom plate, and had a device, somewhat like the jacks of the old-time harpsichord, to keep the opening closed. By depressing a key the corresponding letter was forced out of its magazine into a race. When the type was in the race, it was conveyed by collectors to a common center, where the beat of a small lever forced it down an aperture into a curved channel, along which it was fed in a continuous line. Spacing-even and other operations were done by hand. It is curious to note the breadth of the Church conception, for its

period, although the intervals between the stages prevented the combination of processes from having practical bearing.

In the office of the London *Times* there is now employed, or was up until very recently, a method which is peculiarly similar to the Church procedure. The Kastenbein type-setting

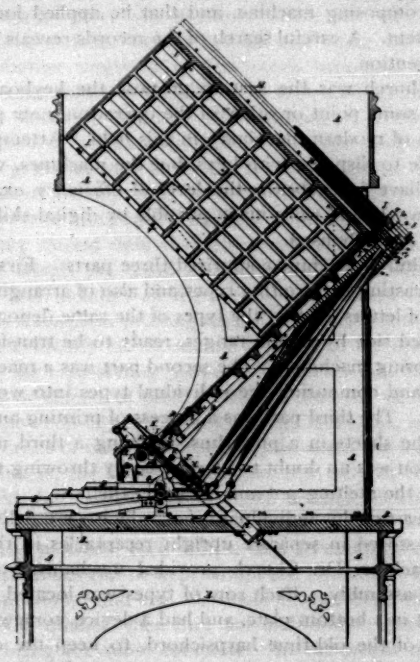

FIG. 1.—Young & Delcambre machine. Vertical side section.

machine, one of the guide-plate class—later to receive attention—is used. Ordinary types are handled, but a large part of them is not distributed, being remelted and cast into new types at a machine from which the letters emanate in long lines, set for position in movable tubes, attachable to the type-setting machine. A distributing machine is also used at intervals in connection with the work.

TYPE-SETTING MACHINES.

Gravity and Guide-Plate Machines.—The most extensive variety of type-composing machines comprises those in which gravity is the principle and a guide-plate is the means to bring the types from their chambers to a common assembly-point. This basic conception arose in 1840, being incorporated in an invention by James H. Young and Adrien Delcambre, of France; it underlies every machine in which gravity is utilized. Illustrations of the machine will facilitate a comprehensive understanding of the principle. A vertical side section, some details and a front plan are shown.

The Young & Delcambre type-setting machine is one of a class extremely large as to numbers. The horizontal bed-

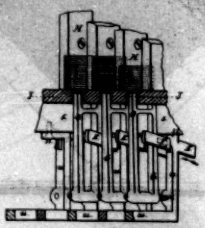

FIG. 2.—Young & Delcambre. Detail showing pusher-frames.

plate *B* (see *Fig. 1*), located in the middle framework of the machine, has bearings *m* attached to it, carrying pins *C* which form the axes for keys *DDD* (like piano keys) to vibrate upon; three rows are visible. The ends of these keys are connected by the joints *8* to the inclined levers *EEE*, on the upper part of each of which are fixed inclined wedges *FF*. These act against the pushing-frames *GG* to force the types out of the chambers *HHH*, as shown in *Fig. 2*. The latter consist of parallel brass bars, raised one above the other, forming open channels, down which the types slide freely onto an inclined plane *J*. The guide-plate is seen at *JJ*, but the front view (see *Fig. 3*) displays it better. It is simply a grooved metal plate, placed in an inclined position, which received the types immediately upon

their being ejected from their chambers and conveyed each of them by its corresponding groove down to cross channels *n*, by which they were guided into the composing stick *K*.

Travelling Belt and Disk Machines.—Another fundamental invention, patented in 1853 and 1857, by W. H. Mitchel, a brother of the Irish patriot, is next in logical order. It also is archetypal. Mitchel's machine was the first type-setting machine to come practically into use. John F. Trow, of New York, used twelve of these machines in 1855, although the

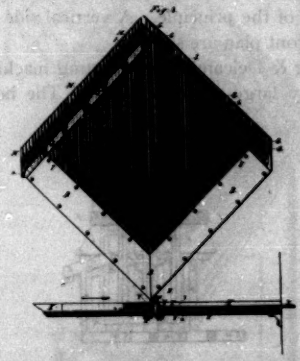

FIG. 3.—Young & Delcambre. Front view of guide-plate.

work was irregular and comparatively unsatisfactory. Mr. Pasko, Librarian of the New York Typothetæ, says that he saw and operated one of the machines in 1859, and that the distribution was faulty, but that the compositor made about 4,000 ems an hour speed. Outside of Trow's, no other office is known to have used the machine in this country.

The view presented in *Fig. 4* is of the Mitchel composing machine. You will note that the employment of gravity is minimized, and that travelling belts of different lengths effect the delivery of the types in the order dropped by the finger-pieces. The resident principle is basic with all machines in which belts, disks and kindred reciprocating mechanism are used to bring the composing units to a common assembling

point. The types are stored in the chambers *g*, the inclination of which is almost vertical to effect rapid descent. The application of power to the pulley *k* rotates the shaft *l*, which has around it a series of endless belts *m*, increasing in length toward the delivery end of the machine and passing over the rest-bars *n* and around small pulleys *i*. Each belt rotates from one of the type-magazines. The depression of the keys effects the release of the types onto these tapes, which carry them through the chute *x* to a diagonally-travelling belt *o*, passing

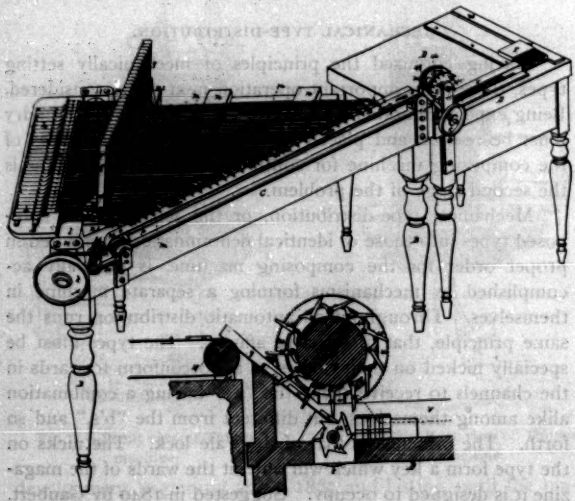

FIG. 4.—Young & Mitchell's machine. Vertical side view and section of conductor.

around pulleys *37* and *39*. The types enter fair upon the center of this tape, by which they are carried with great rapidity (face to the operator) to the roller *39*. They then slide down the conductor *q*, between guide-bars *v w*, fixed on the composing-table, and run along in a continuous line under the eye of the justifier, who cuts off the length needed for a line, spaces

it to measure, and ranges the lines into galley *F*, upon a slightly inclined plane.

In the ideas explained, as fundamental to the Young & Delcambre machine and the Mitchel machine, we see the principles upon which all machines of the type-setting varieties have been based. Whatever of originality has been infused into more modern apparatus lies either in the better adaptation of mechanisms or the modified forms of devices. All employ gravity to some extent, and either the guide-plate or the traveling media in combination therewith.

MECHANICAL TYPE-DISTRIBUTION.

Having cognized the principles of mechanically setting types, there is an important operation next to be considered. Being expensive in themselves, types bought from the foundry must be re-used and placed back again in the magazines of the composing machine for continuous re-assembly. This is the second stage of the problem.

Mechanical type-distribution, or the separation of composed types into those of identical denominations, arranged in proper order for the composing machine, is generally accomplished by mechanisms forming a separate machine in themselves. Throughout all automatic distribution runs the same principle, that of selective affinity. The types must be specially nicked on their bodies so as to conform to wards in the channels to receive them, the "a's" having a combination alike among themselves, but different from the "b's," and so forth. The principle is that of the Yale lock. The nicks on the type form a key which will only fit the wards of the magazine it is designed to occupy. Suggested in 1840 by Gaubert, the idea has been applied and elaborated in many later machines, being now used in all such systems.

MODERN TYPE-SETTING MACHINES.

The Thorne.—Disregarding machines which have not reached the commercial plane, and omitting the half-dozen or so outclassed machines still used in a few offices in Great Britain, two modern type-setting machines—or systems—

present themselves. These are the Thorne and the Empire, formerly known as the Burr machine. The Empire is a gravity and guide-plate machine; the Thorne is a gravity and travelling-disk machine. They will therefore illustrate the latest forms of their respective principles. In both machines specially nicked types are employed for distributing purposes, and only in the Thorne are the composing and distributing functions combined in the same machine.

The Thorne type-setter and distributor, front and rear outline views of which are shown in *Figs.* 5 and 6, represents a

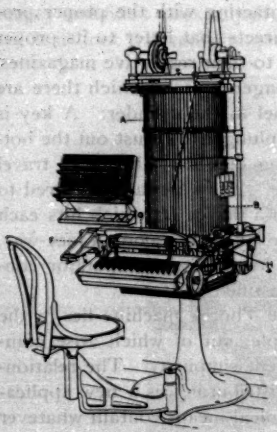

FIG. 5.—Front view of Thorne machine.

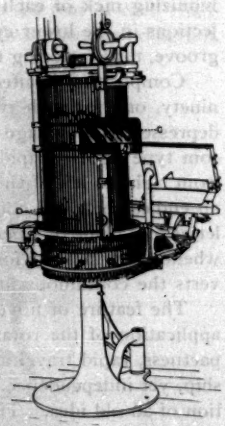

FIG. 6.—Rear view of Thorne machine.

development beginning about 1865 and lasting until the machine was marketed in 1889 or 1890, if memory serves me aright. It is a rotary machine, carrying the types in ninety vertical channels *D* around the periphery of a cylinder and extending its entire length. The mechanisms are in two parts, an upper movable cylinder *A* and a lower stationary cylinder *B*, placed on a common axis, the upper being the distributor and the lower the type-setter. The channels are nearly as deep as the type is high, and a trifle wider than the body of the type

to be contained. But one size of type can, accordingly, be set in the machine. The types lie in their channels, face out, and the letters are the same as ordinary foundry-letter, each character, space and quad being nicked at five points on their bodies, opposite the foundry-nick. The grooves of the distributing cylinder are indiscriminately fed with types at the sides by means of the peculiar form of feed-galley *C*, shown in the rear view, the lines being inserted without regard to order until the matter has all been fed into the chambers. The cylinder then rotates with an intermittent motion, and the harmonizing nick of each type contacting with the proper projections in the lower cylinder directs that letter to its proper groove, thus restoring the types to their respective magazines.

Composition is effected at finger-keys, of which there are ninety, one for each type-channel in the cylinder. A key is depressed and leverage causes a plunger to thrust out the bottom type upon a rapidly rotating disk *E*, with line of travel from right to left of the machine. The types are delivered to an endless belt and conveyed to a device *H*, which lifts each letter to a plane *G*, where the line is forming along a race-way, whence it is pushed forward to its place. An operator converts the continuous line into justified matter.

The feature of novelty in the Thorne machine lies in the application of the rotary principle, out of which arise compactness, rapid travel and apparent simplicity. The relationship, yet independence, of the distributor was a new application of an old idea. The mechanical means contain whatever of novelty there may be in the machine outside of the features treated upon.

The Empire.—The Empire type-setting and distributing machine is a comparatively recent outcome of very long experimentation. It divides with the Thorne machine the commercial patronage of those printing offices which, because of competition, an inherent distrust of line-casting machines and a desire for excellence in product, have sought in machines for handling foundry-letter the way out of their troubles. It embodies no new principles *per se*, and with the exception of a small cam, revolving at high speed in the receiving type-chan-

nel to drive the types forward as they drop, the weight of the letters and the direction of a grooved plate are the only means of bringing the types to the composing point. Distribution is effected in a separate machine, by means of specially nicked types.

The types, comprising eighty-four characters, of each of which a large number is provided, are contained in separate channels in three magazines at the top of the composer (see *Fig 7*). These cases have glass fronts, through which the faces of the letters may be seen. They may be removed when empty and filled cases substituted. To the rear of each channel at its foot is a steel plunger *A*, shown in the small diagram,

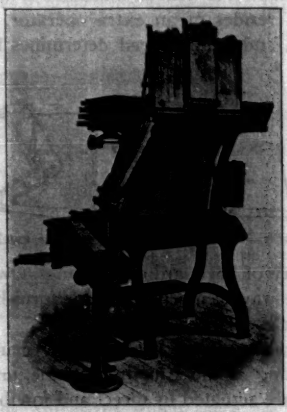

FIG. 7.—Perspective view of Empire composing machine.

Fig. 8. The actuation of a key brings this plunger against the foot of the selected type, in the manner shown, forcing it out of the channel into a groove in the guide-plate belonging to it. This groove directs its course downwards, on a plane inclining backwards, to a pendulum gate, and through the latter into a race where a continuous line of types is forming. A rotating cam drives each letter forward as it drops, and the

line is thus kept moving toward a second operator, who is to justify the composed matter.

The guide-plate in the Empire machine differs in form from that shown with the Young & Delcambre machine, and comprises eighty-four converging grooves cut into a metal plate. This is an improvement, for whereas with the Young & Delcambre guide-plate the descending types had two planes of travel, in the Empire guide-plate they have but one. The principle is alike in both. A glass cover is provided for the entire grooved surface of the Empire guide-plate, the angle of backward inclination given the plate permitting the glass to form the bottom of each channel.

With the Empire, as with all machines of its class, the justifying function resides in an extra operator, whose work is done by hand, and whose speed determines largely the per-

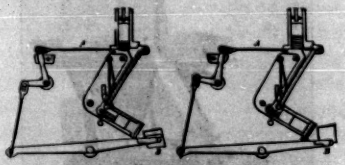

FIG. 8.—**Release mechanism, Empire machine.**

missible rapidity of keyboard operation. Owing to superior facilities in the way of mechanisms for furnishing spaces, the justifying speed is enlarged.

Although the types are not positively manipulated in the process of setting at the Empire machine, and wear is thus reduced, they are actuated by direct and forcible means in the distributor. A perspective view of this machine is given (*Fig. 9*), and a detail or so. One of the latter (*Fig. 10*) shows a single member of a series of type-carriers and also one of a series of slide-devices for selecting the nicks (*Fig. 11*), each of which has nick-pins adapted to enter the exposed nicks of its own particular type (see *Fig. 11a*). The page of type-matter is laid on the galley, and pressed by a weighted follower toward the machine. The first line is lifted by an elevator plate into a channel and is pressed into the machine by another

weighted follower. The first type is cut off by a vibrating mechanism, is received by the type-carrier, gripped and held there by a spring, and passes on in front of each feeler-slide. If the nicks in the type do not correspond with the nick-pins, the types pass on. If they do coincide, they leave the carrier, go forward into a channel in a guide-plate, and are led into a chute which conveys them to the appropriate channels in the case below. Broadly stated, this covers the procedure.

JUSTIFYING BY MACHINERY.

The Cox Machine.—One of the principal functions of type-composition, whether done by hand or at the machine, is that of making all lines exactly even in length to the measure de-

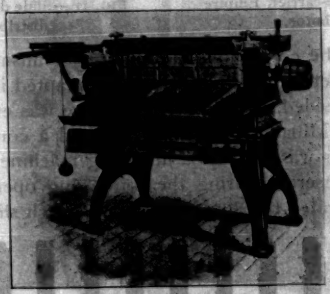

FIG. 9.—Empire distributor.

termined upon. This is effected in hand-setting by the use of spaces of different widths, of which there are five, ranging from the em space, which is theoretically the square of the body, to the thin space, which is one-fifth of the em. By substituting thin for thick spaces it is obvious that a line may be narrowed, while by the opposite process the line may be spread out. Any permutation can thus be made, within approximate limits. To do this by hand becomes almost instinctual; to accomplish it in the machine is quite a different thing. No type-setting machine on the market embodies such a performance; in all of them justification has still to be done by hand

in the usual way. Few inventors of machines dealing with movable types have attempted it; for it is very apparent that an undue complexity must characterize any really efficient mechanism which has to deal with the constantly variable spaces between words. The Paige machine, in which the bulk of Mark Twain's fortune was expended, justified automatically. Mr. McMillan, whose machine was talked of about five years ago, published his solution of the problem about that time. His

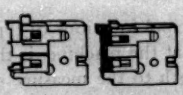

FIG. 10.—Type-carrier, Empire distributor.

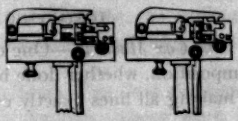

FIG. 11.—Slide device, Empire distributor.

method was the continuous elimination of unsuitable spaces and the replacement of them by spaces adapted in size to the justification needed, and this until the line was evenly spaced out. The McMillan type-setter composed a continuous line of types. This was fed into a justifying machine, thin spaces having been inserted during the composing operation. Mechanisms separated this line into sections, each slightly less in

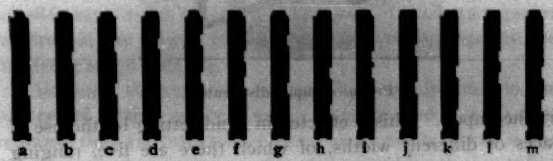

FIG. 11*a*.—Nicked body types for Empire machine.

length than the intended length of the justified line, a wire or stem, longer than the type, being placed at the end of each section. The section was clasped in a holder, capable of expansion to the required length of line, but no farther, and devices were actuated for forcing the thin spaces from the line, successively introducing thicker ones in their places, and repeating this operation with other spaces of the next greater thickness. The process was to be mechanically continued un-

til the line was adequately spaced-even. As is evident, this required a separate machine. As neither Paige nor McMillan machines bid fair soon to reach a commercial status, it is unnecessary to consider them.

Within recent months a Western type-foundry, that of Barnhard Bros. & Spindler, has fostered the rumor of a new type-setting machine. They have such a machine in experimental operation. It is proposed to set and justify movable types in the same machine, and thereby reduce the operatives

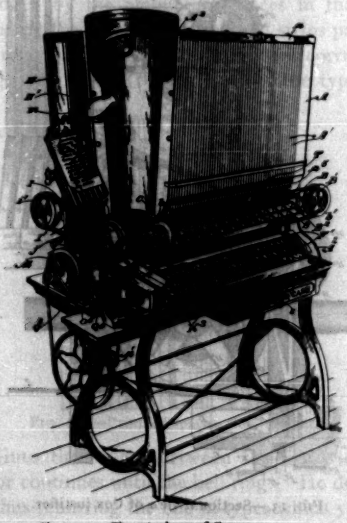

FIG. 12.—Front view of Cox composer.

by one man. Inquiry has developed this machine to be the invention of P. F. Cox, a brother of the inventor of the Cox Duplex Press, whose patents, issued in 1894 and 1895, exhibit the devices to which, as the latest proposals, attention is now directed.

Judging from the plan view here shown (*Fig. 12*), the Cox machine is seen to be a combination of gravity and the travel-

ling-carrier principles, the type-channels being in duplicate groups, one with reservoirs for the upper- and lower-case letters, points, and so on, the other for syllable- and word-logotypes, of which six are noted upon the keyboard. The types are ejected directly from the channels *A*, upon a horizontal carrier-belt, *B*, conveyed to a chute *C*, through which they drop into a race-way or galley, an electrical alarm notifying the operative when the line has reached the point where justi-

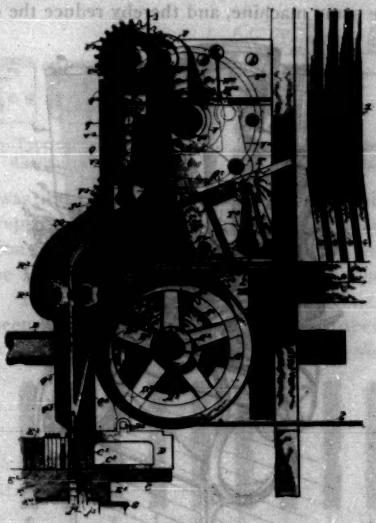

FIG. 13.—Sectional view of Cox justifier.

fication is to begin. A similar series of mechanisms running at right angles with the first provide for setting up the logotypes. The electro-motor *M* actuates the machine, and by manipulating an electric switch between the motor and the wires the operator can stop and start the operations at will. Cases for small caps, italic, and head-letter are provided, from which, by hand, the requisite characters are inserted. The most novel part of the machine, however, is the provision for

making-even. This was doubtless suggested by prior devices, such as elastic spaces—an old proposal—and possibly by the Shucker's wedge used in the Mergenthaler Linotype machine, for instance. Discarding the ordinary straight spaces, the inventor (see *Fig. 13*) employs a spool, not shown, carrying a continuous strip of lead *Y*, which is suitably non-resilient and when compressed will retain its form and not spring back. This leaden ribbon is conducted downward, cut into proper lengths, and fed into the reservoir Q^8. The cutting mechanism *W* is controlled by the amount of spaces in the reservoir. Upon depressing the space key, these lead strips pass through the rapidly revolving crimping rolls *RR*, are corrugated to a thickness equal to that of the en space of the type font, and

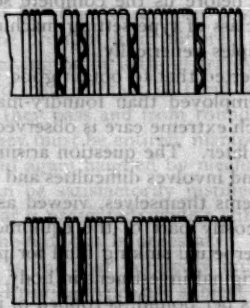

FIG. 13*b*.—Crimped spaces, Cox justifier.

pass down into their place between the words of the line. The operator continues until the bell rings. He depresses another key, thus removing the line of types which you will perceive must be over-spaced. A block moves a defined distance, according to the width of line, compressing the line of types and spaces lineally, after which it is passed into the galley. A machine for distributing has recently been patented. It is understood that the drawings here reproduced are merely offered as illustrating the principles used by Mr. Cox, and not the form of his machine for practical use.

Critically viewed, the proposed machine incorporates one

novel principle, that of crimped spaces (see *Fig. 13b*). The difficulties to be anticipated abide both in the machine and in the product. An exact synchronism must be accomplished in the motions of the mechanisms, the conveyors running at right angles must be accurately timed with the spacing and the justification, while the amount of friction and consequent wear on the types will increase with the positivity of their manipulation. In the lines, as justified by corrugated lead spaces, pressure in a tight lock-up will be unequally resisted by the varying number of spaces in the lines, and this will cause the form to loosen and the types to lift or get off their feet at press.

CRITICAL CONCLUSIONS.

We have thus before us the complete series of machines belonging to the class of type-setting machines, and can now consider the principles generically.

It has been asserted that to obtain good printing no other material can be employed than foundry-made types, in the production of which extreme care is observed. This will have due consideration later. The question arising at this point is purely technical, and involves difficulties and drawbacks which inhere to the systems themselves, viewed as a whole. Type faces are a very costly part of the equipment of a printing office, and are a perpetual sinking fund for profits. It is self-evident that the original investment in body types, which cost from 30 to 50 cents per pound, is robbed of its earning power in exact ratio with the wear and tear outside of that caused by normal usage. To this original investment, about 8 per cent. must be added for extra nicking. It is also apparent that such small objects as printing types, varying among themselves as to size, in every font, set-way, must be handled both by delicate and precise mechanisms before a machine for assembling and distributing them can be satisfactory. Witness the failures of hundreds of inventions in this class, and the seeming abandonment of even the best of them by the vast majority of printing offices to-day! Witness their slow advances! What are the reasons? Partially because the fragility of the objects they are designed to manipulate engenders

distrust of their economy; partially because the requirement that the machines shall handle all widths of letter from the thick m to the thin full point renders the mechanisms inexact and admits the element of chance; mostly, however, because their range of operation has not warranted printers in installing them. The hope is profound that machines in very different lines will better solve the problem. In all type-setting machines, and at some point of their travel, the types are necessarily held, actuated, or propelled forward by more or less positive means, thus engendering friction. Gravity alone is friction-inducing; springs to hold the types, or gripping devices, are still more so. Contrary to accepted opinion, it is not in the number of mechanisms that the real difficulty of such machines resides, but in the exact coördination of movements which must be very delicate yet positive in operation. The types must be brought from different points of storage to a common receiving point without transposition in transit, must be protected from contact of their faces with the surfaces over which they pass and from rounding of their edges at sides or feet; they must be entirely manipulated by mechanisms in setting and again handled by mechanisms in distributing. If they can be satisfactorily justified by machinery a third factor of wear is presented, while a still further extension of precise machine-motions is necessary. Beside these considerations there is one that decidedly militates against machine efficiency. Printing types are subject to a diverse industrial use. After being printed from, they must be restored to the machine. If unclean, sticky or damp, they at once introduce a fortuitous element into machine-composition—a tendency to stop, clog, or to reduce the speed of setting. A machine of this class can handle but one, or at most two sizes of types, and two operatives and a third assistant are required to attend each machine. Without presuming a personal opinion, it would seem that the proportion of the task fulfilled in such systems falls below the efficiencies needful to justify so great an expenditure of mechanical means.

MATRIX-SETTING AND CASTING.

The second great class of machine substitutes for the composition of types by hand is now in order. Here are grouped machines which not only compose the letterpress printing surface, but go farther and produce the letters of which such surface is made up. They not only encroach upon the field of type-composition, but upon that of type-founding as well. There are four varieties of them, which may be touched upon in the order of their evolution, thus:

Machines to impress separate punches, having letters in relief upon their ends, into an impressionable substance, such as papier-maché, and from the matrix thus obtained to cast a stereotype. The difficulties here met with seem well-nigh insuperable, and yet inventors are working to-day along such lines. The failure to precisely align the letters, to secure regularity of drive to the punches, to make-even the lines and to apportion the spacing have ever been primary barriers to successful machine construction.

Soon discovering this, inventors conceived machines for setting up a line of punches formed of movable types, and so forth, previous to impressing them into lead, wood or a softer material. From the assembled stamps a matrix was formed and a stereotype plate was made. Here an advance was noted, in that by using movable elements justification could be done prior to effecting the cast. The difficulties were not less serious than in the preceding machines. The multiplication of stamping dies to equal the frequency with which certain letters were used in a line, and the wear upon the stamps were two obstacles. A machine patented last month by Ole M. Peterson, Chicago, illustrates the last development in this line. More important facts at present engross us.

The third variety of machines proceeds at once from the punch to the matrix, and does away with the former to compose interchangeable matrices, either single or multiple in form, and bearing characters in intaglio, into lines, from which casts are made, corresponding in appearance to a solid line of properly-spaced types.

The single type is the original unit of the printer's art, the

fundamental factor with which are wrought all the intricacies of composition. Being handled as units, types have seemed to present a minimum of productive capacity; being handled together, inventors have thought the process a rapid and economic one. Accordingly the idea of raising this unit of a type by making whole words in one piece was employed by type-founders quite early.

It is this enlargement of the unit that forms the foundation of the slug and matrix machines, the only difference being in the mechanisms for accomplishing the results. In the Mergenthaler Linotype, which is the only conspicuous example that we have for comparison, the unit is raised from the type to the line by means of assembled matrices of brass, into which the line is stereotyped. In a lecture before the Balloon

FIG. 14*a*.—Linotype matrix.

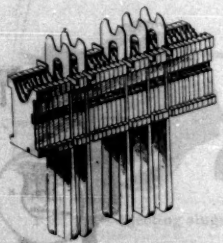

FIG. 14*b*.—Space bands, with assembled matrices.

Society, London, some years since, John Southward traced this general conception back to 1832, when, in Charles Babbage's book, entitled "Economy of Machinery and Manufactures," a method of stereotyping was thus described:

"Instead of composing the work in movable type, it was set up in movable copper matrices, each matrix being in fact a piece of copper of the same size as the type and having the impression of the latter sunk into its surface instead of projecting in relief."

The changeable matrix is the point of novelty in the Linotype; it is the essence of the invention, for it underlies the possibilities of casting properly-spaced types in lines. Although

several machines have been built upon this principle, which seems to have been first exploited by a Mr. Moore, none are now in commercial use excepting the Linotype. The Rogers Typograph, the patents for which were purchased by the company operating the Linotype patents, is out of existence. The Monoline, invented by Mr. Scudder, at one time superintendent of the Linotype shops, is now in interference with a new form of Linotype, proposed by Ottmar Mergenthaler, and hence possesses little of immediate interest. Without prolixity or a needless repetition of details with which all are

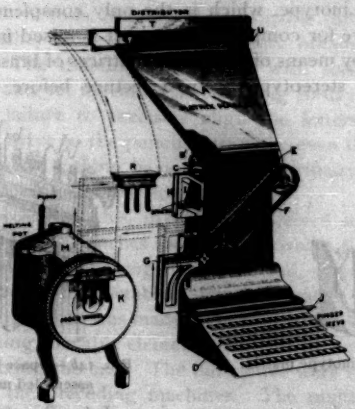

FIG. 14c.—Linotype machine, showing main movements.

familiar, some words about the Linotype, its principle and its product, will not be amiss. This machine has reached its commercial stage slowly and with immense effort. It is the result of over twenty years of study, and, if we may believe the words of its British manager, embodies no less than 1,300 patents and applications. Its history would require a volume in itself.

The Mergenthaler Linotype is a machine in which movable interchangeable matrices are substituted for movable interchangeable types, as used in the type-setting machines. These matrices, of which there are 1,500 in the machine, con-

sist of a flat piece of brass, with a letter or character in intaglio driven into one edge, at *a* (see *Fig. 14a*), and a number of teeth in the upper end, at *b*, which perform the same service as the special nicks given the types for distribution in such machines as have been reviewed. A number of space bands, or wedges (shown with assembled matrices at *Fig. 14b*), are added to these fundamental elements, serving to expand the space between words so as to make the line of matrices justified before the line is cast. By reference to *Fig. 14c*, an admirable plan view published by the Mergenthaler Linotype Company, the process will be made clear. The functions are controlled at a keyboard, the touch upon a key *D* acting upon its escapement *B* to release the corresponding matrix from its

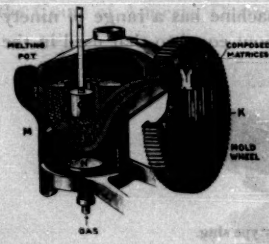

FIG. 14*d*.—Making the cast.

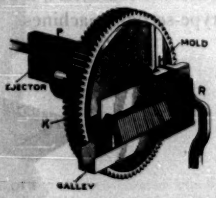

FIG. 14*c*.—Ejecting slugs.

magazine *A*. By gravity, this matrix descends through one of the channels *E*, a modified form of guide-plate, upon an inclined travelling belt *F*, and is carried down into an assembly device *G*, where it awaits the arrival of enough of its fellows to complete the line. Between each word, the space bar *J* is actuated, releasing from their reservoir *H* one of the wedges *I*, which drops into line. When the line is filled, it is elevated, carried to the left and lowered to find a place in front of a slot through a mould-wheel *K* (as shown in *Fig. 14d*), against which it is positively held. The wedges are then pushed up as far into the matrices as they will go. The plunger falls into the metal pot, forces the molten type-metal through the mould orifice into the faces of the aligned matrices, and thus effects a cast. The mould-wheel revolves to an upright position for

the slot (shown in *Fig. 14e*), and by an ejector the cast (see *Fig. 14f*) is forced out between concealed knives to shave it true. Again reverting to *Fig. 14c*, we see the process of restoring the matrices to their magazines and the space wedges to their storehouse. The cast having been made, and before the mould-wheel revolves, the line is lifted vertically from the mould and shifted to the right until the nicks of the matrices engage with ribs on a bar *R*. The space bands are carried to the right into their reservoir; the matrices rise with the bar on an arm, and pass along the wards of the distributor-arm *T* at the top of the machine. It is not needful to explain this operation; it is elucidated in *Fig. 14g*. Much is claimed for continuity of processes whereby the circulation of matrices and spacers takes place. The machine has a range of ninety different characters, a number about equal to that used in the type-setting machines.

FIG. 14*f*.—Linotype slug.

In the chain of operations presented in the Linotype, not a few familiar conceptions are embodied. The machine is practically a digest of everything worthy of adoption that preceded it. The inclined magazine and vertical channels are adapted from the guide-plate; the travelling conveyer is equivalent in function to the travelling belts of one variety of type-setting machines; the distributor is a modification of the principle suggested by Gaubert. It is indeed interesting to see these old-time friends reincarnating so continually before us.

The independently-usable matrix bearing one character is the basic element of the now well-known form of Linotype machine. This is a second type of line-casting machine, the first patents granted to Mr. Mergenthaler being for a machine known as the "band machine," in which a number of type-bars were used, each bearing in relief upon its face the entire

assortment of characters used. The characters were selected for use by dropping each bar to the position required to bring each character opposite a fixed point, when the punches were aligned and a papier-maché form produced. It is unnecessary to say that this type of machine was soon abandoned in favor of the present modification.

Ottmar Mergenthaler filed a patent in 1890 for a form of Linotype machine, which is his latest conception, but which involves a distinct reversal of type to his first species of machine. When application for patent was filed by Wilbur F. Scudder, whose machine is known as the Monoline, it came into interference with the Mergenthaler claims, and the case has been carried through different stages until it is now before the Court of Appeals, District of Columbia. Both inventors

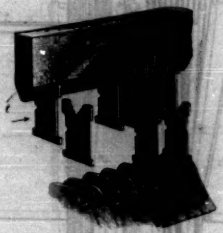

FIG. 14*g*.—Linotype distribution.

claim priority for a multiple matrix, which is not a part of the machine, but is independently usable. The primary aim is, of course, to devise a machine in which a smaller number of matrices than the 1,500 now employed can be used to produce the same number of characters, and in which the mechanisms can be reduced from their present complication. Accordingly, Mr. Mergenthaler proposes a matrix, bearing eight characters on its edge or face, driven one above the other. These matrix-bars he suspends upon wires, somewhat after the fashion in the Rogers Typograph, and brings into alignment by checking their presentation of letter at a selected point in their descent. The drawings illustrate broadly the feature of novelty, showing the selected and aligned matrices, *Fig. 15*, and a front view of

the selected characters presented for casting, *Fig. 16.* It is manifest that in such form of machine the element of cost in supplies is increased, as the destruction of one character by the breaking down of its hair-line wall will necessitate throwing away the entire matrix, which is the equivalent of eight characters. To space out this line of assembled matrices, and thus to close the mould, the orifice of which is shown in dotted lines in one of the figures reproduced, the inventor proposes to employ solid spaces, constructed and operated similarly to the matrices, or to utilize wedges, as shown, each wedge hav-

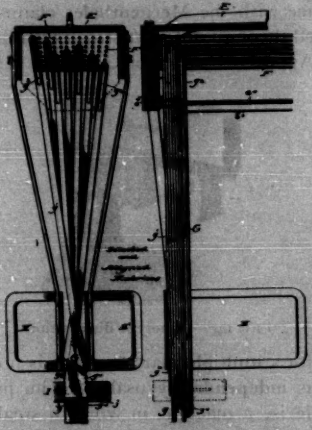

FIG. 15.—Aligned multiple matrices.

ing two members, dovetailed together, which slide one upon the other to widen out the line.

Admitting all of the merits of conception residing in the line-casting machines, their ingenuity and patient battle with mechanical difficulties, little appreciated by those unfamiliar with the problem, some critical treatment becomes advisable. Nobody will allege that any principle or the mechanisms interpreting it are more than a compromise with future systems. The Linotype was commercially the first mechanical substitute

for hand-setting of type which came into anything like widespread use, being confined largely to newspaper work.

Earlier in the evening it was asserted that the perfectness of a machine depended upon the proportion of the whole task accomplished by it, as well as the excellence of the work it executes. The object in view should be fully attained, but with a minimum expenditure of means. This object in printing is three-fold, viz.: quality, economy and quantity. As to scope, the principle of line-casting includes the functions of type-casting, type-setting, type-distributing and type-justifying, with all the attendant advantages associated therewith. It is accordingly broader than the principles resident in type-setting machinery, and for no other reason has met with adop-

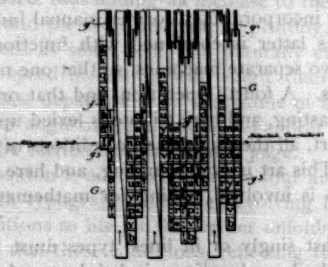

FIG. 16.—Front view of aligned multiple matrices.

tion. Like every prior machine, the Linotype is limited to setting ninety characters or to have recourse to hand-setting other sorts before casting the line. To handle all the characters represented in a full English font would proportionately complicate an already intricate machine, in which the mechanisms are in direct ratio to the operations; as these are numerous the mechanical means are numerous.

THE PRINCIPLE OF LINE-CASTING CONSIDERED.

With line-casting from assembled matrices we have not, as is claimed for these systems, the abolishment of composition, but a substitution of objects to be composed. Instead

of aligning types, they assemble matrices, and in manner precisely analogous. The mechanisms proper to type-setting must be approximately duplicated for this operation. The matrices being regarded as permanent units, just as are the foundry-types, they require distributing as the types do. A second chain of mechanisms is needed to perform this, again somewhat analogous to the type-setting machines, which have a distributor. The nature of the system demands the justification of lines before they are cast, as all corrections required must be made by re-casting the line, and that is a factor of loss at the machine, which is a costly investment. This justifying operation calls into life spacers, which again require separate handling, and thus a third group of mechanical means arises. Thus far the operations run parallel to the type-setting machines, besides incorporating a former manual function (justification). This latter is combined with functions generally embodied in two separate machines, so that one machine does all three things. A fourth operation, and that original, characterizes line-casting, and here tribute is levied upon a precise and accurate art, all the established conditions of which must be set aside. This art is type-founding, and here a fourth set of mechanisms is involved, calling for mathematically exact results.

Whether cast singly or in lines, types must be perfectly rectangular in body and uniform in height to admit of printing from, not to speak of the quality of face which also is necessitated. The ancient art of letter-founding, by the experience of centuries, has brought the conservation of these elements to a plane of certitude. The entire progress of typography, artistically considered, has been thus far looked upon as inseparable from single types. The question is pertinent: Can the principle of line-casting contravene the canons of type-founding and equal quality be gotten along an extended printing surface made at one cast? To this those who oppose the slugs reply that a whole legion of evils is raised by casting lines at one operation, that is by the known systems. Those who favor the slugs say that the commercial advantages offset the deterioration in quality of surface. It is significant

that such deterioration is admitted. Personally, it is my opinion, acquired during the study of the subject for ten years past, that there are other reasons than caprice or tradition for the type-founder's arbitrary standards. His is perhaps the most exact of the mechanic arts. The type-founder has especially recognized the advantages gained in making single types. A smaller quantity of metal has to be solidified in the mould; the nature of the mechanical problem resident in producing an exact matrix for a single character and a mould for casting the body of the letter is greatly simplified; the surface afforded for contraction in cooling is minimized; the foot of the cast can be made true and solid to the extent needed in standing exactly at right angles with the body; and harder metal can be used, thus adding an increase to the permanency of the height and the wear and tear in printing. The larger body sizes, such as small pica, will naturally enable greater accuracy and speed in casting with single than with unified types. The least departure from exactitude of matrix, alignment of face, or angle of presentation will appear in the resulting cast, and be carried into the printed page.

The proposition is advanced that the four and a half centuries in which typography has been evolving have brought the best conditions to life for the further unfoldment of good printing; also that these conditions, reflecting the experience of thousands of progressive printers in whose hands they have exhibited an excellence of production well-nigh inconceivable, are worthy of consideration, and of preservation if they can be shown to underlie the standards proper to quality. It is an open question, which can be left to the judgment without further discussion.

THE LATEST SYSTEM OF MACHINE SUBSTITUTE.

Most recent in order of time and last in the number of systems before the student of the subject engaging our attention is a novel plan, less complex in mechanical means, though broader in scope than preceding systems, and based upon principles which many think are better adapted to conserve quality and economy. The fundamental conception as well

as its subsequent elaboration are due to Tolbert Lanston, of Washington, D. C. The machine is a new species, although here, as elsewhere, a philosophical study will reveal the inductive process which, in the world of invention, is always manifest.

The new principle applied by this inventor may be termed the self-justifying of lines of types by varying spaces between words. The process consists: (1) In ascertaining the length of the proposed line. (2) In finding the space needed to make that line even to the measure. (3) In forming the space types for the line of a width that will absorb the unoccupied space,

FIG. 17.

either by widening each of them if the line is too short or by reducing their width if too long. By the system the spacing is perfectly equalized between words, and the justifying function is made synonymous with casting the space types, thus greatly reducing the mechanical means.

The Lanston Monotype system is embodied in a machine for making and setting single types in the order of their use, arranging them in lines which, when the last letter has been delivered, will be properly justified. The machine is in two parts, the first of which is a keyboard, shown in the views *Fig. 17*, at which the operator sits, recording the characters, the body widths of every letter and space, and the addendum needed to

justify the lines. The operation is purely manual at this point, and as easy as type-writing provided the rules of type-setting are known. The second part of the machine is automatic (run by belt) and here types, similar in appearance to ordinary types, and of commercial character, are produced set in galleys. The operator at the keyboard produces a continuous strip of paper, like that of which a sectional view is shown, at *Fig. 18*, his work recording the characters in perforated holes instead of printing them as does the typewriter. Each key perforates two holes in a line across the strip. One of these holes records the position of the vertical row to which the key belongs; the other records the position of the horizontal row.

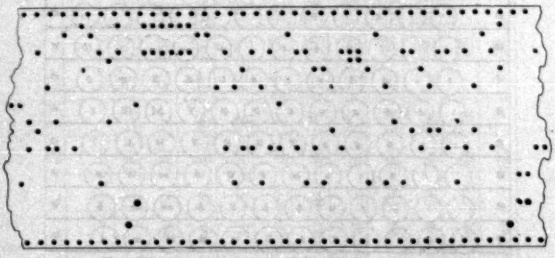

FIG. 18.—Record for composition at Lanston Monotype.

Thus, taking the arrangement of the keyboard, exhibited in *Fig. 19*, the actuation of key representing the upper-case *B* would record holes on the strip showing that it was at the point of intersection of the seventh vertical and seventh horizontal rows that the character was located. The record is thus progressively made, letter after letter, and space after space, the machine meanwhile doing a sum in addition, by the simplest of mechanical means. The end of the line is approached, a bell rings, the operator glances at a space register, which records the number of spaces used in the line, and then by glancing at a scale before him takes cognizance of the space to be added. One second is sufficient to record the addendum on the row of keys at the right, which also perforates holes at the end of the line. All sizes of types from 6-point to 11-point and all

commercial measures can be effected at the keyboard without change, save an adjustment which takes less than ten seconds.

The reel of paper is supposed to bear the equivalent of the finished composition, either in long or short "takes," as may be desired. It is taken to the casting machine, placed in position and the power started. As the strip advances by means of the marginal holes which are fed over spurs, the two perforations representing a type are pneumatically caused to affect the travel of a die-case, the arrangement of matrices in which is like that shown in *Fig. 19a*. This die-case carries matrices in

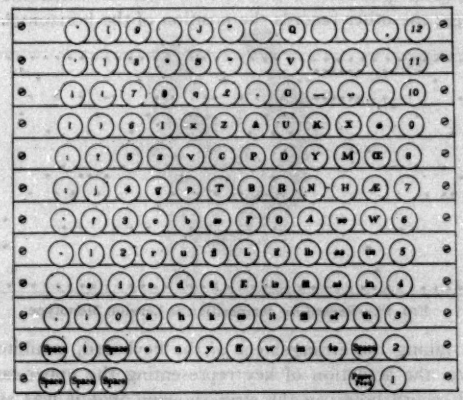

FIG. 19.—Arrangement of keyboard—Lanston Monotype.

the form of small steel cubes, in one end of which is driven an intaglio of the letter, etc.; a solid wall is always afforded to the character; these matrices are arranged in rows, located analogously to the keys on the keyboard, and are carried in a rectangular case, which travels on a compound slide. The cap B which we selected was at the seventh vertical and seventh horizontal rows of the keyboard; it is at the same point in the die-case of the casting machine, see *Fig. 20*. This matrix is accordingly selected by the corresponding or governing perforations, and the die-case caused to travel horizontally on the

slide—matrix end of the steel cube undermost—so as to locate it directly over a mould, closed on three sides, and with an adjustable blade which opens the exact width needed to make the different widths of type. Being centered over the mould, the matrix is depressed to form a tight joint and the metal is forced from a metal pot through a nozzle into the foot of the mould, filling it and the matrix, and chilling to form the body and face of the type together, the type when cast being on its

11 th in us W Æ Œ ø
10 to of at as so H M X ..
9 m fi fl lb A N Y K _
8 w it is If O R D U G V Q
7 ff œ E L F B P & .
6 y k fi fl æ T C Z ø " "
5 n h d u b p v x q S J
4 e a o r c g z ! $ *
3 0 1 2 3 4 5 6 7 8 9
2 ? ! $ ( ) , ; : [ ] {
1 - . ' ^ ~ = ? ( ) ? ?
a b c d e f g h i j k l

FIG. 19 *a*.—Arrangement of matrices in die-plate.

feet. A jet-forming device in the mould breaks the force of the current, prevents the metal from flowing away from the face, and ensures the proper filling. The jet is removed after the cast is made, the type is ejected and by carriers is conveyed to the line in an ordinary galley, in which the matter automatically advances to receive each line. The features of the machine are its simplicity, its directness and its accuracy. Types are made normal; space types are of justifying width; corrections are made as with hand-set types, the machine producing its own sorts; and lines are made-even to practical perfection.

There is no alteration in the methods now in vogue for handling foundry-letter after it is in the galley.

After the complimentary award to Mr. Lanston of the highest honor in the power of the Franklin Institute to bestow, and the publication of so admirable a report about the machine, it is unnecessary to treat upon mechanical details. Technically, some concluding words are called for. First, as to chain of operations. This system includes the production of the compositor's raw material on principles modelled after the latest results of type-founding. It has adapted, not revolutionized, principles admittedly exact and scientific. It elides

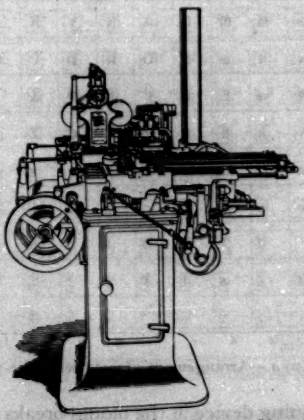

FIG. 20.—Casting machine—Lanston Monotype.

the function of distribution entirely, either of matrices or of types, while embodying all the advantages thereof. It combines the setting of the types with the justification of the lines at one operation and without two series of mechanisms. It employs no gravity, has no travelling conveyers outside of a compound slide with a maximum travel of 3 inches, and involves no restoration of matrices. In a word, it appears that the series of mechanisms have been minimized while the chain

of operations has been lengthened to comprise the varying requirements of composition. No other system has proposed to deal with more than 90 to 100 characters, which is a compro-

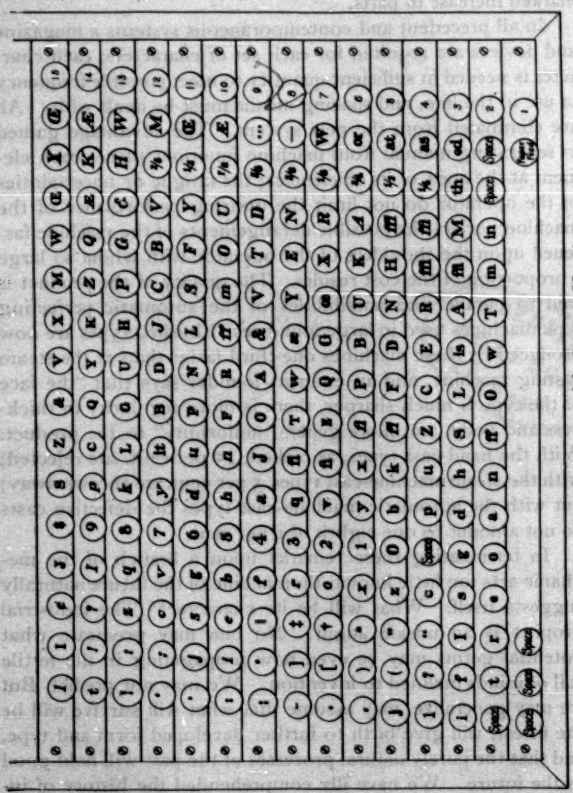

FIG. 21.—Full font keyboard for Lanston Monotype.

mise with the full English font of 226 letters. The keyboard shown in *Fig. 21* illustrates a range for book-work, which is proposed in the Lanston Monotype machine. As the square

die-case may contain any number of characters by merely increasing the rows, the use of fifteen rows, each way, will give 225 characters, with but thirty mechanical movements, and no marked increase in parts.

In all precedent and contemporaneous systems a magazine and devices are required for each set of characters, each character is needed in sufficient quantity to meet possible frequency of use in the line, and spacing means must be dealt with. All are eliminated from the new system. The advantage gained in separating manual from machine functions places each element at the apex of its efficiencies; the fatigue or uncertainties of the operator do not limit the untiring performance of the machine, nor are the possible derangements of the machine fastened upon the shoulders of the operator with whom so large a proportion of the cost resides. The quality of the product is said to parallel the possibilities of the automatic perfecting type-machines used in large foundries. Finished types are now produced by these machines one-third faster than at the steam casting machine, and an eminent founder says that "the face of the type is much sharper, there is more regularity in thickness and body, and more general uniformity" to the product. With the hand-cast types, as picked, 15 per cent. are rejected; with the steam machine-cast types, 5 per cent. are thrown away; but with the automatic machine-cast types the defective casts do not amount to one-eighth of 1 per cent.

In terminating these remarks upon a branch of the mechanic arts too little known, the machine of the future naturally suggests itself. What will be its character? The industrial prophet is an unsafe augur. No one may predicate what potential germs may be even now propagating in the fertile soil of minds inclined to invention. We may not predict. But we may generalize, may assume that what will survive will be the fittest, will give birth to further developed form and type, and that the purely natural processes of the past will hold good in the future. We have illy comprehended the history of invention if we have not learned that a more or less logical sequence of thought lies in every invention. An invention is no special inspiration, it results from the gradual assimilation of

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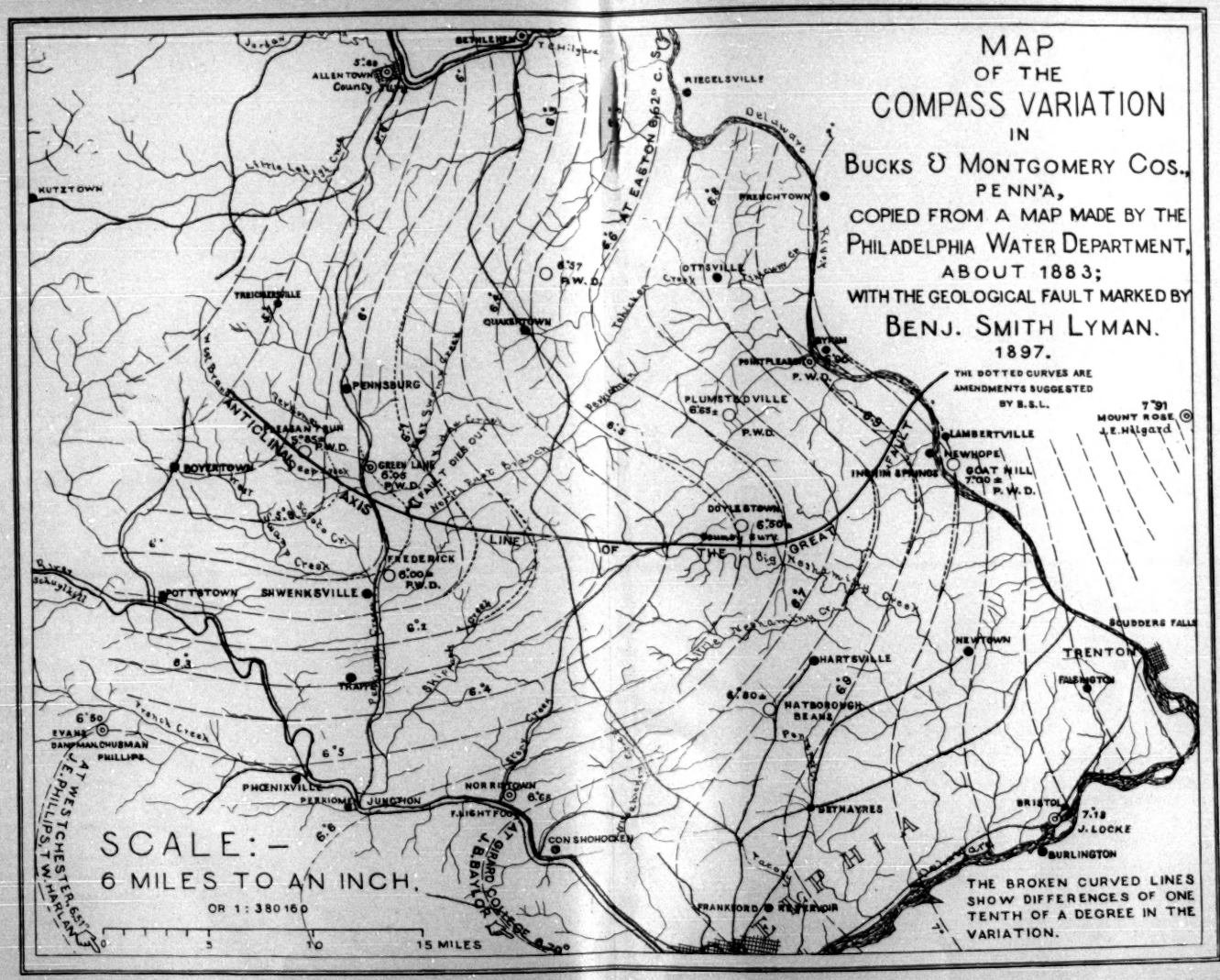

MAP
OF THE
COMPASS VARIATION
IN
BUCKS & MONTGOMERY COS.,
PENN'A,
COPIED FROM A MAP MADE BY THE
PHILADELPHIA WATER DEPARTMENT,
ABOUT 1883;
WITH THE GEOLOGICAL FAULT MARKED BY
BENJ. SMITH LYMAN.
1897.
THE DOTTED CURVES ARE AMENDMENTS SUGGESTED BY B.S.L.
SCALE:—
6 MILES TO AN INCH.
OR 1:380160
0 5 10 15 MILES
THE BROKEN CURVED LINES SHOW DIFFERENCES OF ONE TENTH OF A DEGREE IN THE VARIATION.
ANTICLINAL AXIS
LINE OF THE GREAT VALLEY
BETHLEHEM
ALLENTOWN
RIEGELSVILLE
KUTZTOWN
FRENCHTOWN
OTTSVILLE
QUAKERTOWN
TREICHLERSVILLE
PENNSBURG
PERKIOMEN
PLUMSTEADVILLE
LAMBERTVILLE
NEWHOPE
GOAT HILL
BOYERTOWN
DOYLESTOWN
FREDERICK
POTTSTOWN
SHWENKSVILLE
NEWTOWN
TRENTON
BOUDDERS FALLS
HARTSVILLE
HATBOROUGH
BEANS
THATCHER
PHŒNIXVILLE
NORRISTOWN
BETHAYRES
BRISTOL
BURLINGTON
CONSHOHOCKEN
FRANKFORD RESERVOIR
MOUNT ROSE
J.E. Hilgard
7.91
7.18
J. LOCKE

means already arrived at. The process is purely an inductive one. The machine of the future resides potential in the machine of the present. Which is the fittest of present systems to give it birth I leave you to determine. One thing is certain. The machine of the future will have for its share of the work the entire task which admits of machine execution, it will make the least demands upon operative skill, and the expenditure of mechanical means will be in inverse not exact ratio to its functions.

Mining and Metallurgical Section.

Inaugural Meeting, held April 28, 1897.

MR. JOHN BIRKINBINE in the chair.

COMPASS VARIATION AFFECTED BY GEOLOGICAL STRUCTURE IN BUCKS AND MONTGOMERY COUNTIES, PA.

BY BENJAMIN SMITH LYMAN.

The purpose of this paper is to call attention to a remarkable correspondence between the strongly bent axis of seemingly very irregular curves of magnetic declination and an independently demonstrated profound fault, dying out into a sharp anticlinal, in the new red region of Bucks and Montgomery Counties. The magnetic curves were mapped some years before the beginning of the recent geological survey, that for the first time fully proved the peculiar structure; but the curves had no influence whatever in the interpretation of the geology, and the correspondence was not perceived until long after the geological map was printed.

The magnetic map was made about the year 1883, by the Water Department of the city of Philadelphia, for use in its excellent topographical survey of the Perkiomen and neighboring valleys under Mr. Rudolph Hering. The map records the results of a number of determinations of the magnetic

declination made by the Water Department itself and by the Coast Survey and by other observers, and curves of equal declination were drawn for every tenth of a degree. The curves are so extremely at variance with the simple, nearly straight, lines of earlier less detailed maps, as either to show extreme confidence in the accuracy of the observations, or perhaps even to excuse a suspicion of the possible incorrectness of the curves in some way, especially in view of the acknowledged want of precision of some of the observations, and the absence of any obvious topographical or other occasion for such great irregularity. But the curves are in the main beautifully confirmed and thoroughly vindicated by the underground geology.

The striking feature and dominant peculiarity of the curves is a very strong bend convexly northeastward near New Hope and Lambertville, on the Delaware; but gradually changing towards the west, so that the curves near Shwenksville and Boyertown point still more sharply southeastward. The axis of the bend in the curves is, then, itself greatly bent, nearly to a right angle. The geological survey of the two counties, begun at the end of 1887, has proved beyond a question the existence of an enormous fault, of about 14,000 feet, in the rock beds, almost precisely on the line of the Delaware River end of that magnetic axis, and following the same course past Doylestown, gradually dying out, and west of that town turning northwestward, passing north of Shwenksville, disappearing there as a fault, but continuing as a sharp anticlinal to the border of the New Red and of Montgomery County, 5 miles northeast of Boyertown.

The geological structure of the map of 1893, published by the State Geological Survey, was drawn without the least reference to the magnetic curves, and indeed without any knowledge at that time of the slightest correspondence between them and the geology. The geological map gives the direction and amount of the dip at a couple of thousand points, amounting to a complete demonstration of the structure, and to a full proof of the situation and extent of the fault and of the sharp anticlinal into which the fault runs. The topography

also given on the same map shows that there is no one strongly-marked ridge following the course of the axis of the magnetic curves. Indeed there are more decided topographical indications in the way of long, rather high ridges in other directions. Furthermore, the form of the out-cropping rock beds, sedimentary or igneous, does not correspond in any degree with the magnetic curves.

It is perfectly clear, then, that the remarkable magnetic peculiarity of the region must be closely related to the equally remarkable and completely corresponding geological structure; and if either were in need of corroboration, the confirmation given by two such thoroughly independent pieces of work would be of the strongest kind.

Moreover, some light is perhaps thrown upon the obscure subject of terrestrial magnetism. It is true, the nature of the relation between the magnetic and geological phenomena is not so easily determined; but it seems to become certain that the internal structure of the earth's crust has an important influence upon terrestrial magnetism, even if it be not in any degree its first cause. Terrestrial magnetism and its changes have sometimes been considered explainable by solar influences alone, no longer by direct action of the sun as a magnet, but by the sun's heating the atmosphere or the earth's crust. The present phenomena seem, however, to point to more strictly terrestrial processes as the true cause, and to suggest that the solar influence may partly at least be exerted through the attraction of gravitation as well as through heat. The enormous and locally unequal strains produced by the contraction of the earth's crust in cooling would be particularly liable to be affected by the presence of a deep fault or by a sharp anticlinal. Such lines would be places where the crust has yielded and is readier to yield, and consequently where the strain has been to some extent relieved and is less. The recent occurrence of earthquakes along the New Jersey end of this very fault line shows that the resistance there is less, and that the remaining strain must likewise be less. On such a comparatively weak yielding line the rock beds in readjusting themselves, even where there is no violent earthquake, must

occasion a certain amount, not only of strain, but of friction and heat that might give rise to electrical currents. A decided magnetic effect, too, has sometimes been observed to accompany earthquakes, and in some cases to precede them. In like manner, the strains and yielding or readjustment that may be occasioned by the attraction of the sun and moon might apparently cause electrical currents; and, in fact, magnetic disturbances have been found to correspond, like tides, with the place of those heavenly bodies. Again, the broken or arched form of the rock beds may permit at least a temporary local variation in the temperature of the crust, as affected by the earth's hot interior, that could occasion electrical earth currents. Terrestrial magnetism seems then to arise not only from the manifold action of the sun's heat upon the air and the earth's crust, but from the internal movements of the crust and from the tidal effect of the sun and moon upon the air, ocean and solid earth.

PHILADELPHIA, APRIL 26, 1897.

POSTSCRIPT.

The discussion that followed the reading of the paper suggests the need of a few further remarks. The question was raised whether deposits of iron ore, some of them as much as 50 miles away, could not have so affected the compass variation at the points determined as to give the magnetic curves the peculiar form on the map. But the power of iron ore to affect the magnetic needle at a distance is apt to be exaggerated, somewhat after the fashion of the ancient oriental tales of the lodestone that drew men's boot-nails, and of the seaside mountain that pulled the bolts out of ships' sides. Deposits of magnetic iron ore, though differing much in magnetic force, seldom directly affect the most delicate magnetic needle at a distance of more than a few hundred feet. If they sometimes appear to have a more distant effect on the needle, our present experience would strongly indicate that it is because the iron ore happens to be at some line of such great structural import-

ance as to give rise to a diversion of electrical earth currents. Furthermore, it is hardly conceivable that just these peculiar Bucks and Montgomery forms of the magnetic curves could have been produced by any known deposits of iron ore or trap, whether near or distant, whether strongly magnetic or weakly so, or could have been occasioned by anything else than the closely corresponding equally irregular geological structure.

The number of points (18) where the magnetic declination was determined is not very great, yet sufficiently so to make it impossible to draw any essentially different curves that would conform to them. Nevertheless, it is obvious that the magnetic curves, while not made essentially different, might with the greatest ease be so slightly changed as to have their axis conform exactly to the course of the fault and anticlinal; and several such proposed amendments have been dotted in upon the map. The close agreement of the strongly bent axis of the curves with the geological line of fault and anticlinal is therefore a surprising confirmation of the correctness of the magnetic observations, and at the same time thoroughly indicative of some causal connection between the two phenomena.

Some of the magnetic irregularities that were instanced during the discussion may be wholly unexplainable with our present knowledge of terrestrial magnetism; but if they be not connected with mere temporary disturbances—magnetic storms—we can now see that they may be due to hidden geological structure, in some cases, perhaps, submarine as well as subterranean. It is evident that it is highly desirable that the magnetic investigation of every portion of the earth should be thoroughly carried out, in order to ascertain more fully the world-wide magnetic laws. Such work is, in particular, one of the most important parts of Arctic and Antarctic exploration, one that must be of practical value to surveyors and navigators of every other region.

MOTOR ROAD VEHICLES.

By Joseph Sachs.

[*Concluded from vol. cxliv, p. 233.*]

Arrangement of Controlling and Operating Appliances.—The mechanism put in the hands of the operator for controlling the vehicle, as well as certain other parts of the apparatus which need his attention, should be free from any confusing element and require no technical skill for their proper operation and maintenance. Particularly important and desirable is an arrangement of controlling devices, and, in fact, general mechanism, which is fool-proof, and which will not, under any condition demanding quick and rapid action, confuse the operator.

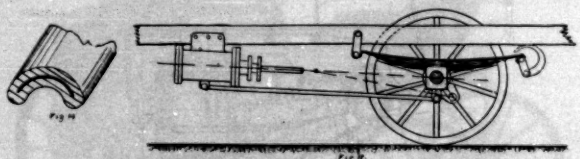
A variety of arrangements of the different controlling levers and other mechanism needed to start, stop or charge the vehicle have been adopted. A separate device controlling each particular action has unquestionably a great deal of simplicity, although perhaps somewhat confusing if the number becomes unreasonable. An arrangement wherein the control of various functions is centered in a single device, which may be given varying movements to produce the necessary results, has probably some advantages.

The general principles above discussed are generally applicable to any form of motor vehicle, but particularly, however, those intended for light service. Following will be a number of specific features in connection with each of the three distinct classes of motor vehicles.

Steam Motor Road Vehicles.—It is unnecessary to speak of the general features of portable steam motive power any more than to say that such motors are easily started and stopped, regulated in speed and reversed. The fuel and water necessary is easily procurable and cheap. Owing to the ease of regulation and control, the gearing and connections between the

motor and the driven elements would be exceedingly simple, and, as a whole, such motive power would not be costly.

Steam motive power, however, for this purpose, in its ordinarily arranged form, has various disadvantages. Aside from the difficulty of evolving a satisfactory small engine and boiler, the power capacity of such motive power is limited. If the demand exceeds the maximum effort of which the motor is capable, while stalling may not result, yet the effect may be equivalent thereto. It is certainly essential that this type of motor as well as any other should be automatic in its action. Solid fuel is therefore scarcely to be considered, and if oil fuel is to be used, its direct combustion in a gas engine cylinder would produce more efficient if not also other advantageous



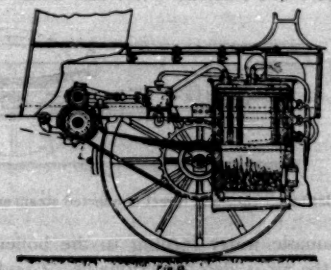
Serpollet boiler tube and direct connected steam engine.

results. Automatic water feeding to the boiler is essential. Exhaust into the air is also objectionable. Condensing apparatus, which would therefore be essential, adds additional complication. Unless the engine and boiler is entirely automatic, the generation of steam when the engine is inoperative would necessitate blowing off either into the atmosphere or elsewhere with any type of water-carrying boiler. Such boilers also have, however, many other objections, in which the danger element is not the least. In addition to the above, such portable steam motors as would be required would undoubtedly require skilful attendance, and would certainly be somewhat unclean and uncomfortable.

Undoubtedly there are most promising possibilities in the future development of the steam-propelled motor vehicle. Rotary engines, instantaneous generation boilers and suitable automatic motor-controlling mechanism will do much, if prac-

tically and commercially operative, to advance the status of the pioneer of motor vehicles. At the present time such motive power would seem to be limited to the heavier type of vehicle.

Amongst recent European productions the Serpollet steam carriages are particularly notable, owing to the peculiar instantaneous-generation boiler with which they are fitted. This boiler consists of several coils of very thick flattened water tubes, having a flat opening approximately one-sixteenth of an inch, between the flattened inner sides of the tube. These tubes are dry-heated to a high temperature by a coke fire, and are directly connected to the engine cylinder. In several modifications, however, automatically controlled oil-firing appara-

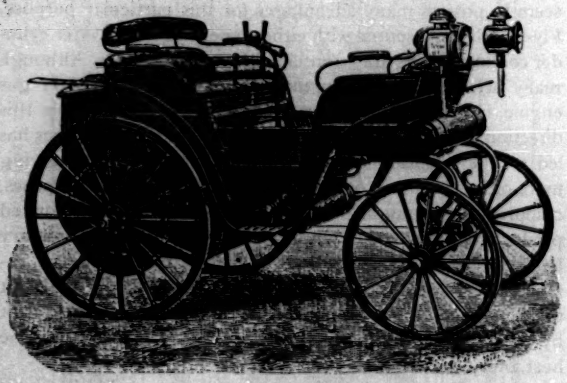


Serpollet boiler and driving gear.

tus is used. Steam is instantly generated and superheated as the water is forced into the boiler tubes by means of hand- and power-operated pumps. The engine is regulated by the amount of steam generated, depending upon the quantity of water forced into the tubes. The supply of the latter is therefore controlled by a valve, regulating the starting, stopping, and varying speed and power of the engine, which is usually of from 4 to 5 horsepower. Exhaust steam is superheated and passes off in invisible vapor beneath the vehicle. These vehicles are quite heavy, but can carry fuel for a journey of from 40 to 50 miles. It is notable that actual tests have shown the efficiency of a combined boiler engine to compare favorably with that of fairly large Corliss units. The success of the vehicle, however, de-

pends upon the ability of the boiler to stand the usage to which it is subjected. Steering in these vehicles is accomplished by the short hub pivoted axle method, and the boiler, engine and mechanism are located over the rear drive wheels, which are connected to a drive shaft fitted with balance gears and operated by the engine by means of a chain and sprocket.

American steam-propelled vehicles have not reached any particular degree of perfected development. The late Stephen H. Roper, of Roxbury, Mass., developed several carriages of this type, the last being a 70-pound (including all mechanism) steam bicycle. Mr. Roper lost his life in experimenting with



A German Daimler motor carriage.

this machine, which could be operated at a speed of nearly a mile a minute, and forms a striking contrast to the massive and heavy European construction.

Under this classification, vehicles propelled by vapors given off by heated liquid other than water may also be included. Alcohol and naphtha engines have given very excellent results as applied to boat propulsion. It would appear that the latter type of motor might also readily lend itself to the propulsion of road vehicles.

Gas and Vapor Motor Vehicles.—There has probably been

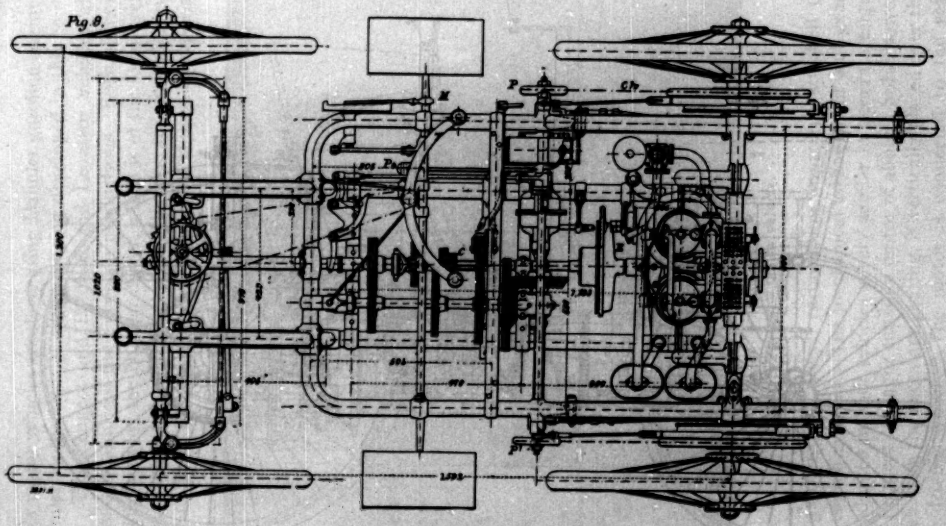
more experimentation with and development of gas and vapor motors for the propulsion of road vehicles than of any other type. This fact is probably primarily due to the peculiar self-contained character of such motors, their light weight and the ease of obtaining fuel for their operation and the small bulk and weight of the latter required for comparatively long runs.

The operation of such engines need scarcely be gone into here. The complete transformation from fuel to power in the engine cylinder, with scarcely any preparation and delay, is a particularly important point in their favor. Both single and Otto-cycle engines have been applied. The latter, however, seem to possess many advantages for this particular purpose. Fly-wheels are essential with either type, and air or water cylinder cooling jackets are essential, although wasteful. Although many attempts have been made to produce the rotary gas engine, nothing feasible has as yet made its appearance in this direction. The impulsive exertion of effort in such engines has led to the adoption of multi-cylinder arrangements, giving more or less balanced operation. For motor vehicle purposes, compressed gas might be carried, but some easily vaporized product of petroleum, such as gasoline, benzine or ordinary kerosene has been generally used. Light oils, giving off inflammable vapors at ordinary temperatures, may be used, but the usual method has been, however, to accomplish this result by the use of slightly heavier oils, and the application of some heat, or by the use of atomizing or spraying vaporizers.

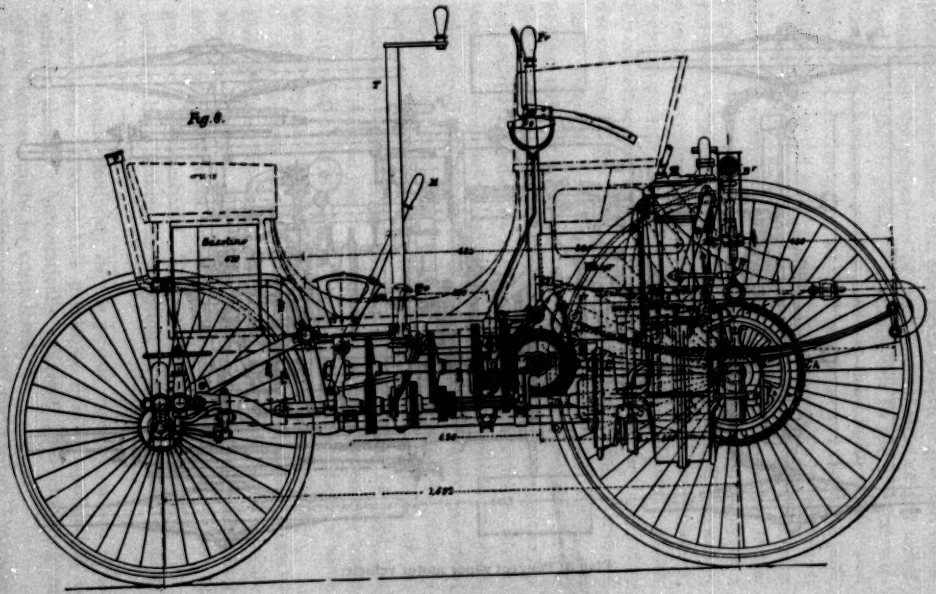
Gas engines are not self-starting, which probably is one of their greatest disadvantages, necessitating the use of separate starting devices. The lack of speed varying and reversing ability in the present forms of engines necessitates the use of gearing for this purpose. The stalling of such engines by overloading them makes the adoption of excess motor capacity advisable.

Automatic flexibility of the power capacity, which is so important a factor in this particular field of application, is entirely absent. Automatically operated gear changing or clutch devices might be considered.

Probably most prominent amongst the various European

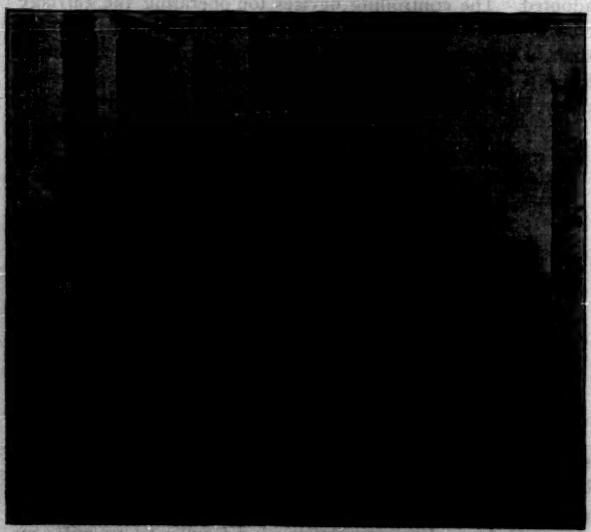


Plan of Peugeot vapor motor vehicle.



Longitudinal section of Peugeot vehicle.

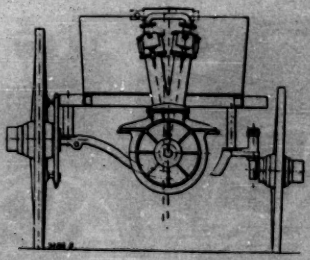
vapor motor vehicles are those using Daimler gasoline engines. Daimler motor vehicles are also being developed in this country. The Peugeot and Panhard and Levassor vehicles are prominent amongst the European productions. Both of these vehicles employ the Daimler motor, which is of the Otto-cycle type, having two water-jacketed cylinders and incandescent tube to ignite the gas mixture. Some heat is used to vaporize



A Peugeot motor vehicle.

the gasoline in a special carburetting apparatus attached to the engine cylinder. The mechanical arrangement and gearing adopted in both vehicles is very similar in general design. The Peugeot carriages employ a motor of about 4 horse-power, which, with the necessary gearing, is vertically placed over the rear driving wheels. The motor is connected to the rear drivers by means of a variable speed gear, of the movable

sleeve and single power clutch type. This variable speed gear is connected to a traverse drive shaft, which is fitted with a balance gear and brake pulley, and connected at each end by sprocket chains to the driving wheels, which rotate upon the fixed axle. Tangent spoked metallic wheels are used, with pneumatic tires, and the steering wheels are operated on short hub pivoted axles. Central pivoting of the axle-tree is also adopted. The controlling devices for operating the carriage consist of a lever for shifting the sliding gears on the main shaft, a foot pedal to release the main power clutch, a brake lever, a reversing lever connected to the separate reversing gears, and a steering shaft and cross-bar connected with the



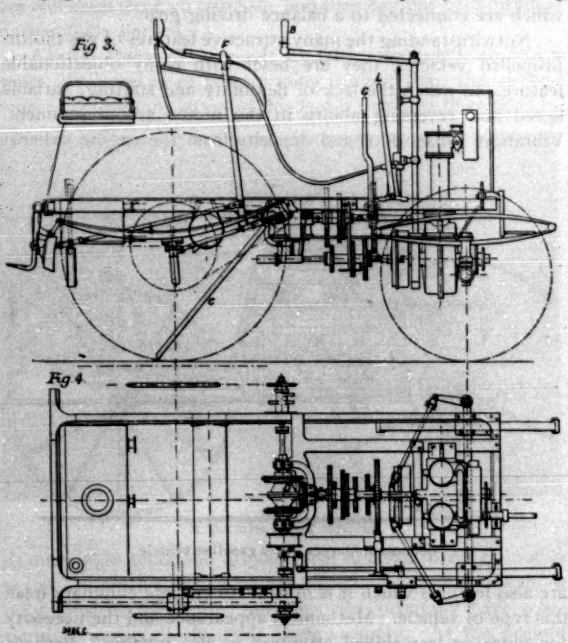
Steering gear and engine of Panhard & Levassor carriage.

short steering axles. The main clutch is always first released before any change in the position of the sliding variable speed gears is made, the engine having previously been started with the gears free. Four speeds, varying from 4 to 14 miles an hour, can be obtained, but only one reversing speed is possible. The steel tubular frame truck construction is adopted for the lower vehicle frame, which is fitted with the necessary mechanism.

In the Panhard and Levassor construction, while the same general gearing is used, the location of the motor and mechanism is reversed, being placed over the steering wheels. The complete vehicle is, however, of much heavier construction than the one previously described, the frame being built to-

gether of wood and steel, mounted, in some instances, on wood steel-tired wheels.

Amongst American gas motor vehicles the Duryea motor carriage has attained particular prominence. The motor used is of the two-cylinder Otto-cycle type, water-jacketed and using gasoline fuel. This motor has a capacity of about 5

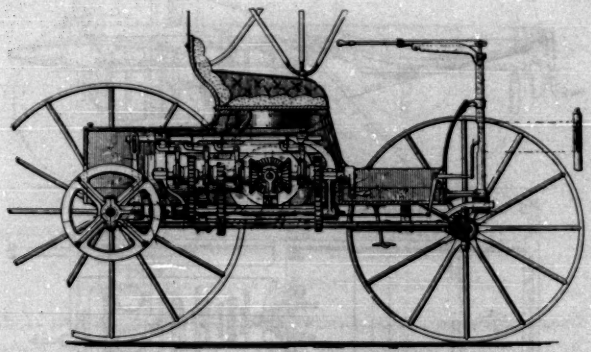


Panhard & Levassor Daimler gasoline motor carriage.

horse-power. Separate clutch-controlled gears or pulleys are adopted for variable speed purposes. A single horizontally-placed controlling lever is used for both steering and the operation of this variable speed gearing. The lever extends from a vertically-placed rod in front of the seat. A vertical

movement of the lever controls the operation of the various clutches, while a horizontal movement is transmitted to the steering gear, which is of the short pivoted axle type, with the line of the pivots striking the wheel base contact. A foot-operated brake arrangement is used. The driving wheels are fitted to a revolving centrally-split axle, the two halves of which are connected to a balance driving gear.

Notwithstanding the many attractive features of gas motor-propelled vehicles, they are beset with many objectionable features, in which the lack of flexibility and starting, variable speed and reversing ability in the motor are pre-eminent. Vibration, noise, odor and deposits from the engine exhaust



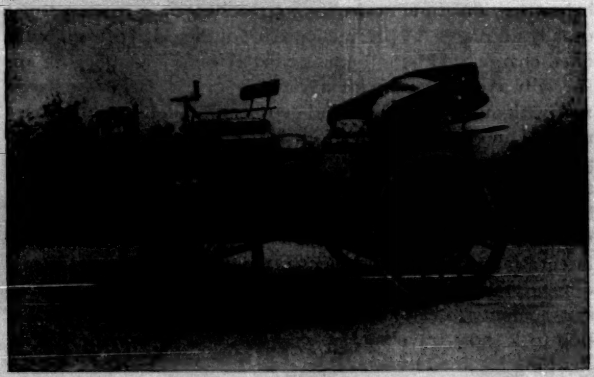
Section of Duryea early gasoline vehicle.

are also features which it is difficult to entirely eliminate from this type of vehicle. Mechanical appearance and the necessity for more or less skilled attention is also notable. Perhaps another objectionable element is due to the storing of large quantities of oil, which would be necessary where numerous vehicles of this type were operated from some particular point. Probably, however, the generally adopted oil for this purpose will have a safe flashing test.

Great improvements are certainly to be expected in the

direction of such vehicles. The production of a gas motor capable of operation at varying speeds and self-starting in either direction, added to the already great advantage resulting from the readily procurable and cheap character of the fuel, will undoubtedly give this type of vehicle a prominent position for many purposes. In their present condition, however, they are still open to much criticism, and their present application is undoubtedly limited.

Electric Motor Vehicles.—It would be impossible to find a more ideal means of transforming energy than the electric motor. The appreciation of this fact is certainly illustrated by



A Daimler motor victoria.

its amazingly successful displacement of other forms of motive power. For this particular application, however, we cannot only consider the motor, but must also primarily have some portable means of electrical energy supply. At the present time the storage battery has been almost solely depended upon for such purposes.

Considering the motor apart from the method of current supply, there can be no doubt regarding its absolute superiority over all other present motors available for road vehicle propulsion. Rotary motion, compact construction, light weight and

efficient operation are all realized. Starting, stopping, reversal and speed variation are easily effected by means of exceedingly simple noiseless and positive switching appliances. The power capacity, with unlimited current supply, is only limited by the heating of the conductors. While all these features give the motor itself a most ideal position, electric motor-propelled vehicles, as a whole, are somewhat hampered, owing to the present necessity of using storage batteries as a current-supplying medium.

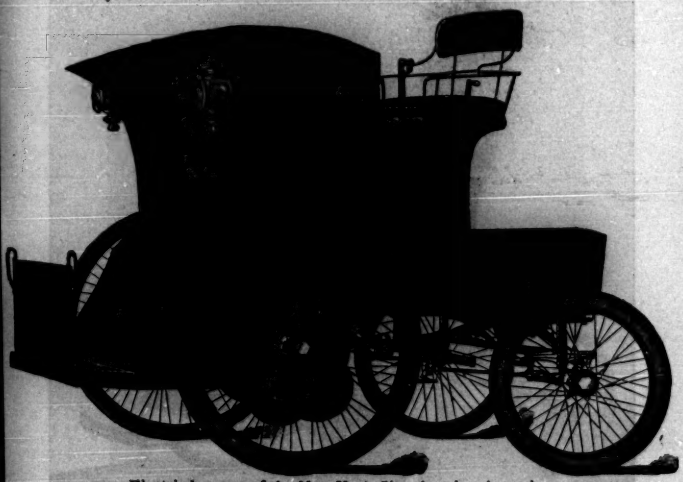
To produce economical results, commercial lead storage batteries must be normally charged and discharged at a point below their maximum capacity. A discharge above the normal usually decreases the life and capacity of the cell, with a certain fixed charge. Although storage batteries for this purpose are specially constructed with a view to give a large discharge rate, with minimum weight and depreciation, yet the battery element of an electric motor-propelled vehicle, even with a comparatively limited traveling capacity, involves a dead weight of almost one-half of the weight of the entire vehicle, which must be hauled about with a constant wasted expenditure of energy. Constant jolting over rough roads is apt to cause some disintegration of the battery element, and by no means the least difficulty, due to the excessive weight of the storage batteries, is its inability to carry long charges and the consequent limitation to a short traveling capacity and only where the proper charging facilities are available.

Electric motor vehicles, however, have so many superior qualities that they give promise of most excellent possibilities even in their present state. Electrically-propelled vehicles seem to have attained particular prominence in this country, and several very excellent constructions have appeared within recent years.

Amongst the recent developments in this direction, the operation of an electric carriage service in New York City is particularly noteworthy. This service includes twelve electrically-propelled hansom cabs, which, in general construction of propelling apparatus and operation, are a type of the well-known "electrobat" vehicles, devised by Messrs. Morris &

Salom, recently investigated by the Committee on Science and the Arts of this Institute, and awarded the John Scott Legacy Premium and Medal. Full details of this vehicle have been presented to the Institute in a paper by Mr. Salom, which was published in the *Journal.**

Various electric motor vehicles, including the hansom cabs, broughams, delivery wagons, etc., have been constructed by Messrs. Morris & Salom. The hansom cab, as



Electric hansom of the New York City electric cab service.

used in New York City, is a four-wheeled affair, weighing, complete, about 2,000 pounds. The fore body resembles the ordinary hansom cab lines, but extending rearwardly therefrom is a battery box body. Four wheels of the metallic tangent-spoked type with heavy pneumatic tires are used. Each set of wheels is independent and is separately attached to the body, which is supported on the axles through compound flat springs. As with the earlier vehicle, rear steering and

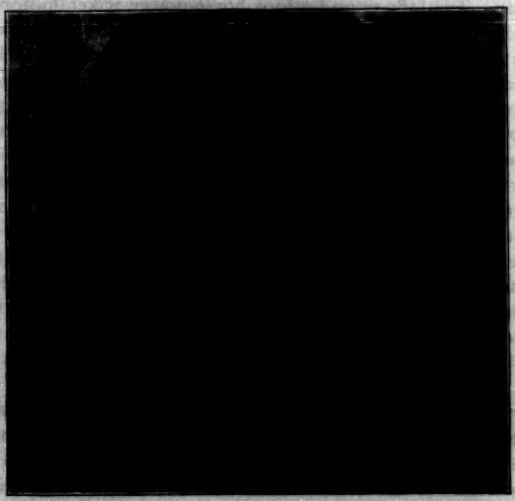
*See *Jour. Frank. Inst.*, **141.** 278

front driving wheels are used. Each driving wheel rotates on roller bearings on the ends of the fixed axle, and each wheel is separately geared to a single 1½ horse-power electric motor through a single reduction internal spur gear and pinion. The steering wheels are hub-pivoted to the ends of the fixed rear axle.

Morris & Salom electric brougham.

Four trays, of eleven 100 ampère hour "chloride" cells each, making a total of forty-four cells, form the battery equipment. These are placed into the box body through the rear door and connections are automatically made. The batteries and motors are controlled by a single series parallel

cylindrical-controller located under the driver's seat and having an upwardly projecting handle at the side of the seat. Three speeds forward and one reverse speed are obtainable by turning the control cylinder to either side of its normal position. At the first speed, from 4 to 5 miles per hour, the batteries discharge at about 16 ampères; at the second, from 7 to 9 miles, the discharge current reaches 21 ampères, and at the



Columbia electric carriage under test, showing battery and motor.

third speed, of about 15 miles per hour, 34 ampères. With the lowest speed, the vehicles have a traveling capacity of from 30 to 35 miles, and at the highest, only about 15 miles.

The rear steering wheels are hub-pivoted on the ends of the fixed rear axle and are turned in parallel planes by the spade-handled operating lever in front of the driver's seat, which is moved forward or back to steer the vehicle to either side. A foot-operated brake-lever, close to the steering lever, connects

with rubber-roller brake shoes acting on each of the drive-wheel tires.

The Riker electric motor carriages embody many excellent structural features. One of the early Riker vehicles weighs about 1,800 pounds, and has a seating capacity for four persons. The entire upper body rests on a tubular steel frame or truck, fitted with all the propelling mechanism, excepting the battery, which is placed directly under the seats in the upper body. Two 180-pound 3-foot horse-power Riker motors are each separately geared to spur wheels attached to the spokes of the rear driving wheels. Pneumatic-tired steel wire wheels are used, rotating on ball bearings. Current is supplied by thirty-two 100-ampère-hour chloride accumulator cells, weighing 800 pounds, with a capacity sufficient for a four-hours' run at 10 miles per hour over ordinary level roads.

Speeds either way, varying from about 5 to 27 miles per hour, are obtained by the operation of a battery-controlling switch connected to a hand-wheel on the side of the front seat. The front steering wheels are supported on short pivoted axles connected by suitable rods to a horizontally pivoted lever, which can be locked in any position by a slight downward pressure. A band brake on each motor shaft is operated by a foot-brake in front of the operator.

A very elegant electric motor carriage has recently been perfected by the Pope Manufacturing Company, and is named after the well-known bicycles made by the same concern, the "Columbia" electric carriage. In general appearance this vehicle takes the form of a modified phaeton, with highly finished black enamel box body and folding hood, accommodating two persons. This body is supported on an entirely separate tubular steel truck or lower frame, resting on three traversely placed flat compound springs. The complete vehicle weighs about 1,900 pounds. The frame is fitted with the motor gearing and steering appliances, while the storage batteries are placed in the rearwardly extended box body, which has a door at its free end, through which they are handled.

Ball-bearings and pivots have been adopted throughout.

Tangent-spoked metallic pneumatic-tired wheels are used. The front steering wheels are 32 and the rear driving wheels are 36 inches in diameter. The wheel track measures 54 inches, and the distance between front and rear wheel bases 6 feet.

The driving wheels are fitted to the ends of the revolving centrally-split rear axle, which is hung in four ball-bearings from the frame. A balance gear connects the split axle at the junction, the driven member of which is geared through an intermediate gear member to the pinion on the hollow motor armature shaft, which is placed concentrically around the revolving axle, so that the motor is at the side of the balance gear. Special care has been exercised in the construction of the motor, which is of the ironclad multipolar type, with a sectional series field. It has a normal capacity of 2 horse-power, weighs only 120 pounds, and will readily stand an overload of 100 per cent. for some time.

Forty-four "chloride" cells, arranged in four sets of eleven each, comprise the battery equipment. These occupy two sliding boxes, which can easily be placed in or taken out of the battery box. They have a capacity of 70 ampère hours, at a discharge rate of 25 ampères, and weigh, complete, 850 pounds. At 12¼ miles per hour this battery equipment will give a traveling capacity of 30 miles.

Individual operating mechanism is used to control each function. The steering handle is placed centrally in front of the seat and resembles an ordinary car-brake handle. Its movement to the right or left is suitably trasmitted to the short pivoted axle steering gear and wheels, the latter being arranged to move at different angles. A foot-brake lever in front of the seat is connected by a rod to a peculiar double-acting brake band engaging with the outer shell of the balance gear on the drive shaft. The control of the motors and batteries is accomplished by means of a cylindrical control cylinder for effecting 4 speeds by arranging the batteries and motor fields in different series parallel combinations. These speeds vary from 3 to nearly 15 miles per hour. A separate switch is provided for reversing purposes. This switch suit-

ably connects the armature terminals, and is operated by a foot-push and arranged so that it can only be changed when the speed cylinder is in its normal position. Interlocking mechanism is used to prevent its operation at any other point.

It has been particularly desired to make the mechanism of this vehicle automatic in its action and proof against careless handling. An unique device for this purpose consists of an automatic wattmeter-controlled charging and discharging switch. When charging the batteries they may be left in the vehicle, it being simply necessary to insert the plugs of the charging cable into suitable receptacles, which are so arranged that no mistake can be made. The batteries have some resistance in series for charging purposes, so that the cable may be directly connected to any direct current 110 volt circuit. When the maximum charge has been reached, the recording wattmeter automatically energizes the operating magnet of an electro-magnetic switch, which is then opened. The light and non-mechanical appearance of the complete vehicle are notable features.

It is probably unnecessary to dwell upon the various advantages of electrically-propelled road vehicles. Noise, odor, mechanical appearance and other objectionable features are absent. Cleanliness and simplicity and safety of operation are attained to a point far in advance of vehicles otherwise propelled, and a variety of peculiar controlling and operating methods are possible. One or two motors can be used with equal facility. In the latter case, it is possible to control the motors in steering to give the variation in rotation of the inner and outer wheels, although practice has shown that with such motors this arrangement is not essential. Electric braking, either by means of electrically-operated mechanical brakes directly supplied with current from the battery, or dynamic operation of the motor as a dynamo, acting either through a resistance or such magnetic brake device, would be productive of results impossible with other methods. It is also particularly noteworthy that by a suitable arrangement of automatic devices the entire control and maintenance and operation of

the vehicle can be made almost entirely automatic, guarding against carelessness or excitability on the part of the operator. With no other motive power and auxiliary appliances can this feature be as satisfactorily and efficiently covered.

If it were possible to substitute some other portable current-supplying medium in place of the storage battery, which would be free from the objectionable weight of the latter, the electrically-propelled vehicle would undoubtedly stand without a peer. A lighter storage of electrical energy, the transformation of heat directly to electricity, or its production by some direct chemical means, is to be hoped for in the future. At the present time it would appear that the storage methods in general use are the sole means available for the solution of the electric-motor vehicle problem. The electric motor is an ideal method of applying energy for propulsion. Why not use a portable self-contained prime mover to generate the needed energy? A gas or vapor motor is a most excellent form of portable motor, the main difficulty existing in its application. Why not combine the two? Certainly the results possible are most promising. Quite true that additional mechanism is essential, but certainly the combination of a gas engine, directly connected to a high-speed dynamo, which, in turn, supplies the motors, cannot be either heavier than the storage supply arrangement or more complicated than the direct gas-motor method. The writer has evolved some new methods in this direction. The objections to the gas motor, in regard to lack of flexibility, starting, etc., have been overcome by peculiar methods of operation. It is reasonable to expect that such a method will not only have all the advantages of the electric vehicle, but also be cheaper to build and operate.

In conclusion, it is entirely unnecessary to bring to your attention the various advantages due to this coming change in the propulsion of at least a large per cent. of road conveyances. Beyond all doubt these are sufficiently ample to rapidly bring about the substitution when the perfected mechanically-propelled road vehicle appears.

STELLAR DYNAMICS.

By Luigi d'Auria,
Member of the Institute.

This most stupendous of astronomical problems, which has defied the efforts of astronomers and physicists, and before which the law of universal attraction seems powerless, can be shown to find an easy solution in the inter-stellar ether, provided the latter is assumed to be ponderable. This fact was proved for the first time by the writer in a paper read before the American Philosophical Society of Philadelphia, May 13, 1897, under the above title, and he now proposes to give his problem a more detailed and exhaustive treatment.

Let us imagine the ether to spread out from the center of the universe spherically to any distance beyond the remotest star, and assume ether to be ponderable. Denote by R and D, respectively, the mean radius and mean density of the earth; by g, the mean gravitative acceleration at the earth's surface; by σ, the density of the ether; by x, the distance of a material body from the center of the universe, and by φ, the acceleration suffered by such body at such distance. Then we can write the following proportion:

$$\frac{\frac{4}{3}\pi R^3 D}{R^2} : g = \frac{\frac{4}{3}\pi x^3 \sigma}{x^2} : \varphi,$$

from which we get

$$\varphi = g \frac{\sigma x}{D R} \qquad (1)$$

Considering the center of the universe as origin, an elementary fall of the body towards such center will have to be designated by $-dx$, and we get, from the well-known equations of dynamics,

$$-\int \varphi \, dx = \int u \, du = \frac{u^2}{2},$$

or

$$u^2 = -2g\frac{\sigma}{D\,R}\int x\,d\,x,$$

in which u represents the velocity acquired by the body in falling from its original distance ρ, to the distance x, towards the center of the universe. Integrating between the limits ρ and x, we get

$$u = \sqrt{\frac{g\,\sigma}{R\,D}(\rho^2 - x^2)}; \tag{2}$$

and when the body passes the center, it will have for its maximum velocity

$$v = \rho\sqrt{\frac{g\,\sigma}{R\,D}}. \tag{3}$$

Of course, it is understood that the body in question will oscillate about the center of the universe continually if undisturbed, and its amplitude of oscillation is $2\,\rho$. The period of its oscillation is found by means of the following equation,

$$t = 2\int_0^{\rho}\frac{d\,x}{u},$$

in which, substituting the value of u given by equation (2), and integrating between the limits, we get simply

$$t = \pi\sqrt{\frac{R\,D}{g\,\sigma}}, \tag{4}$$

which expression being independent of the amplitude of oscillation, shows that all bodies within the ethereal sphere would perform their oscillations with the same period about its center.

If the oscillating body is considered moving upon an extremely elongated ellipse, its period of revolution would be expressed by $T = 2\,t$, or

$$T = 2\,\pi\sqrt{\frac{R\,D}{g\,\sigma}}. \tag{5}$$

If a body within the ethereal sphere be subjected to a tangential impulse which would cause it to revolve around the center of such sphere in a circular orbit of any radius such body would have to satisfy the following equation, viz.:

$$\frac{v^2}{\rho} = \varphi = g\,\frac{\sigma}{D}\,\frac{\rho}{R},$$

from which we get

$$v = \rho\sqrt{\frac{g\,\sigma}{R\,D}}.$$

Now the period of revolution of such body is,

$$T = \frac{2\,\pi\,\rho}{v} = 2\,\pi\sqrt{\frac{R\,D}{g\,\sigma}},$$

which is identical with (5), and would seem to indicate that the period of revolution of a body revolving around the center of the ethereal sphere is the same whether such body moves in an elliptical or circular orbit, independently of the dimensions of such orbits.

If the body moves on an elliptical orbit whose semi-diameters are a and b, then denoting by x, y, the coördinates of the point occupied by the body at any time, its component velocities, parallel to a and b respectively, will be

$$\sqrt{\frac{g\,\sigma}{R\,D}\,(a^2 - x^2)} \text{ and } \sqrt{\frac{g\,\sigma}{R\,D}\,(b^2 - y^2)};$$

and if we denote by u the absolute velocity of the body in its orbit we must have

$$u^2 = \frac{g\,\sigma}{R\,D}\,(a^2 - x^2) + \frac{g\,\sigma}{R\,D}\,(b^2 - y^2),$$

or

$$u = \sqrt{\frac{g\,\sigma}{R\,D}\,(a^2 + b^2 - z^2)}, \qquad (6)$$

in which z represents the distance of the body from the center of the ethereal sphere.

In order now to test the sufficiency of the ether in produc-

ing the proper motion of stars, we take for the density of the ether the value given by Maxwell, which is

$$\sigma = 5.32 \times 10^{-19} d, \tag{7}$$

d being the density of atmospheric air. If we express d in terms of the mean density of the earth, we get approximately

$$d = \frac{D}{4234},$$

and consequently we find

$$\frac{D}{\sigma} = \frac{4234 \times 10^{19}}{5.32}.$$

With $R = 20{,}880{,}000$ feet, and $g = 32.2$ feet, we get approximately

$$\frac{D\,R}{\sigma\,g} = 517924 \times 10^{22}.$$

and

$$\sqrt{\frac{D\,R}{\sigma\,g}} = 7.2 \times 10^{13}.$$

Substituting this value in (5) we get for our constant period of revolution

$$T = 45.24 \times 10^{13} \text{ seconds},$$

which amounts to a little over *fourteen million years.*

[Maxwell Hall, an astronomer in Jamaica, from considerations of an entirely different character, concluded quite recently that our Solar System is revolving probably around a center with a period of *twenty million years.*]

The greatest proper motion yet observed is that of the Star 1830 Groombridge. Its present velocity is no less than *one million* feet per second. If this star is moving with this velocity in a circular orbit, or is moving in an elliptical orbit of any eccentricity, and is at present at its nearest distance from the center of the universe, our equation (3) will determine either the radius of its circular orbit or the length of the major semi-diameter of its elliptical orbit, by substituting in such equation

$v = 1{,}000{,}000$, and solving for ρ. Doing this, we get, approximately,

$$\rho = 1364 \times 10^{13} \text{ miles} = 2200 \text{ light years},$$

which, being within reasonable estimates of star distances, shows not only the sufficiency, but the plausibility of our hypothesis to account for the amount of proper motion observed in stars.

If the ether is ponderable matter, of course, it is only natural that it should be also the physical basis of the universe out of which nebulas and stars were born; and we may picture before our minds the universe, in the first stage of its appearance in infinite space, as an immense ethereal nebula obeying the law of universal gravitation.

Beginning at the time when ordinary nebulas, and even stars, started to make their appearance in such universe, all bound towards its center, one of the inevitable results must have been the appalling collisions of many of these bodies in reaching this destination, spreading fragments and cosmical dust, vivid with light and heat, in every direction, to great distances. The bodies which, by a happy *contre-temps* in starting on their eventful journeys, passed the center of the universe unharmed, must have necessarily met with other bodies coming from opposite sides, towards this center, at various distances from it. Some collisions must have occurred, giving place to larger bodies animated by a more or less rapid motion of rotation, and in many cases these collisions must have scattered fragments to great distances in directions crossing with those followed by the previous fragments emanating from the center of the universe. By mutual attraction, many of these fragments must have combined into small systems endowed with considerable kinetic energy of revolution, but all bound to reach the center of the universe at some future time. The bodies escaping collision after passing through the center of the universe, and the bodies coming towards this center, must have acquired great relative velocities when passing close to each other. Imagine two such bodies in the act of passing by one another. Their mutual attraction must, inevitably,

have forced them out of their rectilinear paths, causing them to revolve, each in an elliptical orbit of large eccentricity, one body moving in one, the other in the opposite direction around the center of the universe; and it seems natural to admit that, without going through this process, a star or a nebula would have very few chances to continue its existence.

The passage of bodies close by each other, but at considerable distances from the center of the universe, would give them very much less relative velocities than in the case just contemplated, and consequently must have opened a field for the formation of binary systems. These systems, however, being still bound for the center of the universe, must have ultimately met their fate there, and must have started the formation of a great central mass endowed with motion of rotation, to be swelled later on by the fall of the innumerable fragments, or systems of them, already on their journeys towards the great center of attraction.

From what has already been shown, it can be reasonably inferred that in the evolution of such universe, the surviving stars and nebulæ would, almost without exception, be found to revolve in elliptic orbits of various dimensions and eccentricities, with different velocities, around the center of the universe; that the planes as well as the axes of these orbits would be found to intersect each other at all imaginable angles; that the motion of stars and nebulæ in their orbits would be found to take place in every conceivable direction; that stars and nebulæ moving in elliptical orbits, when passing each other close enough and with a proper amount of relative velocity, would give place to binary and multiple systems; and that, finally, the perspective of the proper motion of stars and nebulæ, so organized, would, from any point of view, appear bewildering and confusing in its aspect.

Going back to the great rotating mass accumulated at the center of the universe, there was only one possible future for it, and that was a gradually increased rotation by condensation, the expanding into an immense disc extending to great distances, and finally, the breaking up of such disc into millions of stars, all revolving in the same direction around the center

of the universe. These stars may well represent the Milky Way.

Stars and nebulæ on each side of this Milky Way must have been more or less affected by its attraction, according to distance, and must have gradually approached towards its plane, forming a condensation of stars diminishing from this plane towards its poles.

We need go no farther into details to show how forcibly the dynamics of stars follows under the hypothesis of a ponderable ether as the physical basis of the visible universe; and in a separate paper, now in course of preparation for another publication, we propose to show that this hypothesis is perfectly compatible with the functions ether is supposed to perform, and is also sufficient, without the intervention of any other law, but the one which governs the motion of planets and comets in their orbits around the sun, to account for almost every phenomenon we are acquainted with in molecular physics and molecular dynamics.

THE FRANKLIN INSTITUTE.

Stated Meeting, Wednesday, September 15, 1897.

Mr. John Birkinbine, President, in the chair.

On an IMPROVEMENT in the ART of GALVANIZING.

By George C. Reese,
Member of the Institute.

The object of this paper is to call attention to a recent advance in the art of galvanizing, by which many objectionable features are obviated, which have heretofore characterized the methods of manufacturing generally in use, thereby insuring not only greater rapidity of production, better quality of product, economy in fuel, labor, capital, interest and other charges, but also resulting in the production of new forms of galvanized wire or coated material heretofore unknown to the trade.

For certain special uses of iron and steel, it is desirable, in many cases, to give the metal a coating which will be a protection from oxidation, and at the same time facilitate the uniting of different parts by soldering the coatings together. This is effected by immersing the iron, after it has been properly cleansed and prepared, in a bath of molten zinc, whereby a coating of zinc is obtained which firmly adheres to the iron, by reason of the alloying action between the two metals. This operation is universally known as galvanizing (which, it may be remarked incidentally, is a misnomer), and differs very little from tinning and lead coating.

The protection from oxidation, in galvanized wire, is fully accomplished when a very thin and uniform coating is obtained; but where the wire is afterwards to be subjected to twisting and bending, such as twisting the ends of telegraph wires together, or the weaving of wire cloth, the wire should be soft and the zinc as pure as possible, so that the elongation of the two metals is as nearly equal as possible, otherwise the coating is liable to crack and peel off.

In galvanizing, it is necessary that the iron operated on should remain in the bath until it acquires the same temperature as the molten metal, or the coating will not adhere; this, in the case of galvanized wire, necessitates the maintenance of large tanks of molten zinc, containing often as much as 50 to 60 tons of metal.

In the usual method as heretofore practiced, a number of previously prepared wires are drawn slowly through the molten bath of coating metal, and, upon emerging therefrom, are passed through tightly enveloping wipers of asbestos or other material to remove the excess of coating upon their surfaces. This method is necessarily slow, because the time of transit through the bath is fixed by the fact that the temperature of the wire must be raised to, or approximately to, that of the spelter in order that it may receive a thin, durable coating; and also because of the frequent breakage of the wires from the tension exerted upon them by the action of the drawing and reeling devices.

The speed at which No. 12 wire is coated being from about

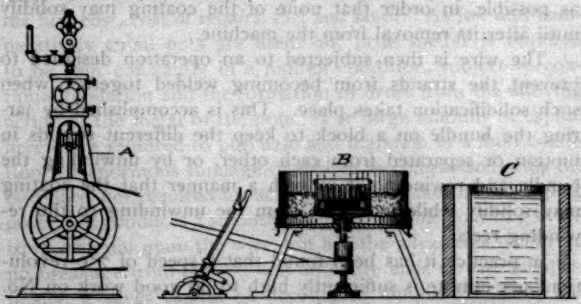
50 to 60 feet per minute, this gauge runs from ¼ to ½ mile, and smaller gauges several miles in length, per bundle. Hence, although many devices have been adopted for increasing the production and decreasing the breakage, by complicated apparatus for drawing larger numbers of wires through the bath and the wipers, and by giving notice of undue strain exerted upon the wires by tension, the output of each bath was and necessarily will be low, in the use of this old method. This in itself called for the use of a large number of galvanizing pots in order to bring up the output of the factory to the paying point. Any increase in the speed of drawing inevitably requiring a corresponding increase in the length of the pots because the time of transit through the bath could not be shortened below the limit before mentioned.

The constant maintenance of an enormous tonnage of spelter in a fluid condition, constantly exposed to oxidation and to the destructive alloying action of the metallic surfaces of the pots, entailed great loss, trouble and annoyance by the rapid formation of "dross" and oxides. The percentage of dross should be kept as low as possible to insure proper fluidity and working of the bath. This dross consists mainly of spelter, which granulates after alloying with a very small percentage of iron, and, being heavier than the pure spelter, sinks to the bottom of the bath. Its formation, in conjunction with the necessity of drawing the wires slowly through long, deep, wide baths, has entailed great loss.

It will be seen, therefore, that the method of drawing wire through a bath and wipers is radically defective in its principle of operation, of progressively subjecting succeeding portions of the coating to the action of the wipers by tension, apart from any defects in apparatus used for such purpose; yet, notwithstanding, it has continued in use as the only practical method heretofore known to the art for giving a good and reasonably uniform coating to ordinary or fine wire.

By a newly patented method, the practicability of which has been demonstrated at the works of the Sharon Hill Galvanizing Company, Darby, Pa., the samples of coated wire which are now exhibited for your inspection are some of the

many forms in which wire can be coated in a cheap, rapid and efficient manner, at a speed heretofore impossible to attain, and of a quality, uniformity and finish of coating unequalled by that of the wiping process. This is done by a method of operation which absolutely prevents the breakage by tension and the imperfect ends which occur in the wiping method; it obviates also the necessity of keeping a large tonnage of spelter constantly heated and exposed to the formation of dross by alloying and oxidation, reduces investment, capital, interest, fuel, labor and other incidental charges, and enables the manufacturer, with a small cheap plant, to exceed the output of the large costly plants now in use. The securing of these results is obtained by a radical departure from the



A, motive power; *B*, centrifugal separator; *C*, spelter pot.

principle of operation of the old wiping method of progressively applying tractive force to successive parts of the wire or bundles; and in lieu thereof each and every part of the coating upon the wire is simultaneously subjected to the action of a centrifugal strain greater than the combined adhesive and capillary attraction acting to retain the superfluous material upon the surface of the wire or between the strands of the bundle, thereby leaving a smooth, flexible, adherent and uniform coating upon the surface of the product. This is effected by means of an apparatus shown herewith, in which *A* represents the motive power, *B* a centrifugal separator, which is

generally known as a hydro-extractor, and *C* the galvanizing bath.

The coils or bundles of wire are cleansed by acid and prepared in the usual manner to receive their coating. A whole bundle is then dipped into the bath of melted spelter, and when it has received a thorough coating, it is removed to, and dropped into the centrifugal separator, which may be in motion for small light coils, or the machine may be started after heavy bundles are placed in it. After a short space of time the wire attains the same speed as the machine, and the surplus coating is almost instantly thrown off against the safety shield. The machine is then stopped and the bundle removed. This part of the process is performed as quickly as possible, in order that none of the coating may solidify until after its removal from the machine.

The wire is then subjected to an operation designed to prevent the strands from becoming welded together when such solidification takes place. This is accomplished by jarring the bundle on a block to keep the different strands in motion or separated from each other, or by unwinding the bundle and rewinding it in such a manner that the coating may solidify while in transit from the unwinding to the rewinding reels.

In practice it has been found that a speed of 750 revolutions per minute is sufficiently high to do good work on No. 20 wire in bundles of 10 inches diameter. Larger gauges require less speed, on account of retaining the heat longer and because less capillary attraction is exerted where the spaces between the wires are greater; variation of the initial heat of the bath also causes variation in the cohesive force of the spelter, and variation of the chemical constituents of the bath is also a factor, as some baths work more fluid than others at a given temperature. Smaller gauges of wire and smaller bundles also call for an increased speed of rotation; but in general, I have found that the minimum and maximum speed of rotation required, are about 500 and 1,500 revolutions per minute when operating on 10-inch bundles.

The chief advantages of this method are as follows: As it is

only necessary to subject an entire bundle of wire for a few seconds of time to the action of the centrifugal separator instead of drawing a small number of strands through wipers at the slow speed of not more than 1 foot per second, as in the old wiping process, the bundles are finished as fast as they can be raised to the proper temperature and coated in the galvanizing bath, hence the tonnage output, per pot, is enormously increased, especially so on fine wires, some of which are many thousands of feet in length to the single pound, and which could not be made for general consumption on account of the prohibitive price of such galvanized product. The great increase of product from each pot renders few of them necessary in plants of large tonnage capacity, thereby saving a large proportion of the first cost, cost of repairs, fuel and labor. As few and comparatively small pots are used, but little spelter is required to be kept constantly in a molten condition, subject to continual oxidation and the formation of dross from the alloying action of the metal of the pots. The large amount of capital heretofore required to purchase and maintain in a fluid condition the enormous tonnage of spelter in comparison with the output, is not required for such purpose. Like the old wiping process, it produces a smooth, uniform, flexible coat of galvanizing material upon the wire, but has the advantage of having no breakage from tension and no waste ends on the bundles; finally, it saves capital on account of diminished labor, fuel consumption and power, concentrates the size of plant, requires less ground, fewer buildings, repairs, etc., and enables the manufacturer of galvanized wire to produce, in a cheap and rapid manner, many forms of wire heretofore unknown to the trade.

Among the new articles produced by this method is barbed wire, which has been galvanized after it has been twisted into shape and formed into bundles. When wire is galvanized before being barbed and twisted, much of the coating cracks and peels off and the points of the barbs, where they are not coated, become blunt by rusting. This new article, can not only be produced much more cheaply, but is also more durable, and, as the points of the barbs are completely coated, it retains its efficiency much longer than the old kind.

Twisted fence bands are rapidly galvanized in the bundle, by this method, after they are formed.

The samples of wire rope here shown illustrate in a remarkable manner how perfectly the superfluous coating material may be eliminated by centrifugal action, and yet leave a perfect coating upon the wires.

Wire cloth is galvanized by the old method from two meshes to eight meshes per lineal inch; but in cloth finer than eight meshes so many of the meshes become permanently closed with the coating material, that it is impossible to produce a marketable article. By the new method cloth of any fineness may be coated if the speed of rotation be increased with the fineness of the cloth operated on. I have here samples of 12 x 13 fly wire and No. 16 mesh, which I believe was the first cloth of this kind ever successfully galvanized after being woven.

Franklin Institute.

[*Proceedings of the stated meeting held Wednesday, September 15, 1897.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, September 15, 1897.

MR. JOHN BIRKINBINE, President, in the chair.

Present, 83 members and visitors.

Additions to membership since last report, 7.

The Actuary submitted the following preamble and resolutions as the action of the Board of Managers on the resolutions relating to the Smoke Nuisance, submitted to the Board by the meeting of May 19, 1897, viz.:

Whereas, The Board of Health of the City of Philadelphia has requested the Franklin Institute to discuss the question of Smoke Prevention, and to offer practical suggestions relative thereto; and,

Whereas, The use of bituminous coal for fuel is increasing in this city and is likely so to continue in the future; and,

Whereas, It appears from testimony presented to the Institute that it is practicable to burn bituminous coal in suitably constructed furnaces without creating a smoke nuisance;

Therefore, Be it resolved, that it is the opinion of the Institute that the continuous or frequent discharge of dense black smoke from furnaces of stationary boilers is avoidable, and should not be permitted within the city limits.

Resolved, That the emission of smoke from locomotives and furnaces other than those of stationary boilers, might be greatly reduced if the co-operation of firemen and employers were enlisted with an earnest intention to abate the nuisance, and more especially could the railway companies be induced to use anthracite coal or coke in the furnaces of the locomotives used for local service in the train-yards within the city limits.

Resolved, That a copy of these resolutions be sent to the Mayor, to the President of the Board of Health, and to the Presidents of City Councils.

On motion of Mr. Wm. H. Thorne, duly seconded, the preamble and resolutions were adopted without dissenting vote.

Vacancies in the Committee on Science and the Arts, reported by the Secretary, were filled by the election of Mr. Wilfred Lewis for the unexpired term of Mr. John H. Cooper, deceased, and Mr. W. C. L. Eglin for the unexpired term of Mr. N. H. Edgerton, resigned.

Mr. George C. Reese, of Darby, Pa., made a communication describing certain improvements in galvanizing, which he had invented, and exhibited a number of samples of work. (Referred for publication.)

The meeting then proceeded to the special subject of the evening, namely, the presentation of descriptions of improved furnaces and automatic stokers. Communications were presented from the following: Babcock & Wilcox Company, New York; Mr. W. R. Roney, describing the Roney automatic stoker, manufactured by Westinghouse, Church, Kerr & Co., of New York; Mr. W. R. Tatnall, representing the Hawley Down-Draught Furnace Company, of Pittsburgh; Mr. Wm. H. Thorne, representing Messrs. Wm. Sellers & Co., Inc., manufacturers of the Vickars automatic stoker; and Mr. Alfred Wilkinson, representing the Wilkinson Manufacturing Company, of Philadelphia, manufacturers of the Wilkinson stoker.

The various speakers illustrated their remarks with the aid of models and lantern slides.

A number of communications, bearing on the same subject, were postponed until the stated meeting of October 20.

Adjourned.

WM. H. WAHL, *Secretary.*

COMMITTEE ON SCIENCE AND THE ARTS.

[*Abstract of proceedings of the stated meeting held September 1, 1897.*]

MR. G. MORGAN ELDRIDGE in the chair.

Reports on the following subjects passed first reading:

A Testing Machine for Measuring the Intensities of Impulsive Forces. B. W. Dunn, Lieut. U. S. A., Frankford, Phila.

Process of, and Apparatus for, Manufacturing Mosaics, etc. Herman C Mueller, Zanesville, O.

Arndt's Econometer, Joseph Wilckes, New York.

Cazin's Percussion Wheel, American Impulse Wheel Company, New York

Improvements in Vehicle Wheels, E. L. Markley, Royersford, Pa.

Reports on the following subjects were adopted :

Rochester Time Recorder—Willard & Frick Manufacturing Company, Rochester, N. Y.

ABSTRACT.—This invention provides a means by which a workman personally records upon his individual time-card the time when he enters and leaves the workshop. The device is controlled by a clock, and the system of operation renders unnecessary the services of a clerk or timekeeper. (For special details the report must be consulted.) The report speaks very favorably of the simplicity and effectiveness of the recording mechanism, and also of the simple and inexpensive card system employed, and concludes that the invention represents a decided advance in time-recording systems. The John Scott Legacy Premium and Medal is recommended. [*Sub-Committee.*—H. R. Heyl, J. M. Emanuel, Charles James.]

Window Ventilator.—Percy A. Sanguinetti, Philadelphia, Pa.

ABSTRACT.—The device is intended to secure better ventilation of existing apartments, and consists essentially of a deflector of wood or other material extending the full width of the window, and supported at its ends by metal plates, which are secured to the sash-beads. The deflector rests in grooves contained in these plates, which govern also the changing the angle at which the deflector may be set. Separate grooves provide for the insertion of a wire screen for intercepting dust.

The object of the apparatus is to admit fresh air under the sashes of windows, to which it may be attached, and at the same time to deflect it upwards so that it will diffuse and not cause disagreeable draughts.

The report finds that the use of deflectors similar in purpose to that employed in this device have been known and used prior to the date of the Sanguinetti patent, but admits the novelty and utility of the method of adjusting and securing the deflector at any desired angle. [*Sub-Committee.*—Stacy Reeves, Charles L. Hillman.]

Step-up and Step-down Transformer System of Electric Distribution.—Rudolph M. Hunter, Philadelphia.

ABSTRACT.—The report deals with the claim of the applicant for an invention of a method of transmitting power by means of step-up and step-down transformers, and deals chiefly with the consideration of the claims of the U. S. letters-patent No. 460,071, September 22, 1891, and collateral evidence submitted by applicant as to priority of invention. The report concludes that the evidence submitted is not sufficient to substantiate applicant's claims. [*Sub-Committee.*—Clayton W. Pike, Chairman, E. A. Scott, Carl Hering, Thomas Spencer, H. W. Spangler, L. F. Rondinella, Paul A. Winand.]